NOTES

ON

MILITARY HYGIENE,

FOR OFFICERS OF THE LINE:

A Syllabus of Lectures

AT THE U. S. INFANTRY AND CAVALRY SCHOOL.

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THESE notes represent the essence of the lectures on Military Hygiene delivered to the Class of 1889, at the Infantry and Cavalry School. The lectures were expansions of this syllabus, and were chiefly compilations with additions, comments, and illustrations from personal experience. Parkes's great work is the chief but not the only source whence the principles were drawn.

Originally prepared for the convenience of student officers, it has been thought that this abstract might be acceptable to officers of the line generally.

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NOTES ON MILITARY HYGIENE.

I.

THE SELECTION OF SOLDIERS.

Nature of Military Hygiene.

1. In general terms military hygiene means the care of troops. This duty is ever present.

2. It concerns line officers as they control the daily lives of men, and staff officers as they supply their food, their clothing, and their habitations.

3. It is of importance to soldiers because, removed from much independent action in relation to their own sanitary care, honesty requires they shall not be injured by the system imposed on them, and to the state because nothing is so costly as disease and nothing so remunerative as the outlay that augments health and thus increases the amount and value of the work done. (Parkes.)

General Physique.

4. The whole military fabric rests upon the physical character of the individuals composing it.

5. The recruits must be trustworthy in physique before the military character can be developed, and extreme care is necessary to avoid accepting blemished men who will break down under strain.

6. Recruiting is, therefore, a serious duty to be both conscientiously and intelligently performed.

7. It is not true, as sometimes assumed, that every full-grown man who supports himself by hard manual labor will make an efficient soldier.

8. Because all his senses may not be keen, nor all his joints flexible; and although accustomed to vigorous work he may not be sound.

9. Unsound men, enlisted on account of special skill as craftsmen, can never be depended on for the field and will certainly be absent in battle.

10. When in doubt as to a recruit, reject.

11. Some allowance may be made for blemishes not affecting organic soundness that have originated in the service, in men who technically re-enlist.

12. Because their education in military matters and their habits of discipline compensate for some minor weaknesses.

13. But all variations from the standard must be carefully noted on the enlistment papers.

14. Men failing to re-enlist who seek to come in later with blemishes are rarely acceptable.

15. "An army raised without due regard to the choice of recuits was never yet made a good army by any length of service." (Vegetius, A.D. 300.)

Age of Recruits.

16. Maximum for cavalry, 30 years; for all other arms, 35 years; minimum for musicians, 16 years; for all others, 18 years. No limit for subsequent enlistment.

17. During the Civil War volunteers were accepted between 18 and 45, but men were drafted only between 20 and 45.

18. The so-called "enrolled militia" are between 18 and 45.

Height and Weight.

19. Present minimum height, 5 feet 4 inches. Maximum height for cavalry, 5 feet 10 inches; for all others as determined by relation to maximum weight.

20. Cavalry, no minimum weight; maximum, 165 pounds. For all others, minimum weight, 128 pounds, maximum, 190 pounds.

21. An exceptionally good recruit may be accepted at 125 pounds, if filling all other conditions.

22. Physiological relation between height and weight, used as the standard for recruits, is: To include 5 feet 7 inches, 2 pounds to the inch and add 7 pounds for every inch above 5 feet 7 inches.

23. Application of rule for weight: Multiply the whole height in inches by 2; multiply the difference between 5 feet 7 inches and a greater height by 5; add the products.

Example: To find the normal weight of a man 5 feet 10 inches. 5 feet 10 inches $= 70$ inches; $70 \times 2 = 140$; 5 feet 7 inches $= 67$ inches; $70 - 67 = 3$; $3 \times 5 = 15$; $140 + 15 = 155 =$ weight.

24. The maximum height for cavalry is fixed, and for other troops is determined by applying this rule to the maximum weight (190 pounds).

Example: 5 feet 7 inches $= 67$ inches; $67 \times 2 = 134$; $190 - 134 = 56$; $56 \div 7 = 8$; $67 + 8 = 75 = 6$ feet 3 inches for infantry or artillery.

25. It is permissible to accept recruits a few pounds either under or over the relative weight, but those under weight are to be regarded with disfavor unless

reduced by some manifestly temporary condition. Exceptions as to over-height are made by Adjutant-General.

26. It is better that men should be over than under weight if muscular, but obese men should be rejected.

27. The present minimum height, 5 feet 4 inches, is merely a regulation that may be changed at any time; but experience has shown that 5 feet 2 inches is practically the lowest limit for efficiency, and when men less than 5 feet have been accepted they have been found to speedily break down as a class from want of physical strength.

Chest Capacity.

28. Chest capacity consists of the two factors, chest measurement and chest mobility, and is one of the elements for determining vigor.

29. Chest measurement is the mean of the measures of chest circumference, taken a little below the nipple with the arms hanging naturally, at the end of forced expiration and forced inspiration.

30. Chest mobility is the difference between the extremes of expiration and inspiration.

31. Speaking generally, the more nearly the chest approaches a barrel in shape the better.

32. The circumference at the nipple should be about one-half the height of the man.

33. The capacity of the lungs increases with age to a certain period and with height and growth, so that men from 5 to 6 feet high inspire from 174 to 262 inches.

34. The physiological rule to determine the relation of chest capacity to height in recruits is: Be-

tween 5 ft. 4 in. and 5 ft. 7 in. there should be a mean chest measurement of 34 in. and there must be a chest mobility of 2 in., with *a minimum at expiration of* 32 *in.*.

35. Above 5 ft. 7 in. the mobility must be 2½ in., and for every inch of stature add one-half inch to chest measurement.

36. Table showing the Relation between Height, Weight and Chest Capacity.—(*Greenleaf.*)

Height.	Weight. For each inch of height, allow	Chest measurement.	Chest mobility.
5 ft. 4 in. to 5 ft. 7 in.	2 lbs...............	Half height plus half inch.......	2 inches.
5 ft. 8 in. to 5 ft. 10 in.	2 lbs., and 5 lbs. additional for each inch above 5 ft. 7 in..............	Half height...	2½ inches.
5 ft. 11 in. and above.		Slightly less than half the height.	2½ inches.

Minors.

37. A minor above the age of 18 may be enlisted with his parents' consent, provided he is in all respects the equal of a man of 21.

38. This proviso is extremely important, and officers not insisting on this standard or not recognizing the physical deficiencies of a bright lad of nineteen are liable to serious error.

39. All military experience is opposed to the enlistment of minors for active service.

40. Napoleon after Leipsic said: "I must have grown men; boys serve only to fill the hospitals and encumber the roadsides."

41. In Egypt, in 1798, the 68th from Bombay was composed chiefly of boys. Fever broke out on their

passage, they lost nearly half their number and continued so sickly that they were reëmbarked and sent back.

42. But the 61st, over 900 strong, nearly all old soldiers, were 16 weeks on board ship and landed with only one man sick.

(It is probable, however, that the condition of the transports and the care exercised over the men had much to do with their health in both of these cases.)

43. In the Peninsular war, 1805–14, 300 men who had served 5 years were regarded more effective than a newly arrived regiment of 1,000 recruits who were lads.

44. In the Mexican war, 1847, our medical officers constantly reported that the inferior physique and especially the youth of the recruits materially increased the sick and mortality lists.

45. In the Crimea, 1854–5, when notified that 2,000 recruits were ready, Lord Raglan replied that "those last sent were so young and unformed that they fell victims to disease and were swept away like flies, so that he preferred to wait," rather than to have young lads sent out as soldiers.

46. Lord Hardinge says that, "although no men were sent [to the Crimea] under 19 years of age, yet when sent out it was found that instead of being composed of bone and muscle they were almost gristle."

47. In General Roberts's march from Cabul to Candahar in 1880, "it was the young soldiers who succumbed to its fatigues while the old soldiers became hardier and stronger every day."

48. The Franco-German experience coincides with all this.

49. The influence of age upon disability in the field during the Civil War has not been shown by authentic statistics, but the experience of all officers serving with troops then will confirm the general statement that very young men generally broke down first under exposure and hardship.

50. In peace, the Surgeon-General's report for 1885 shows that up to the age of 25 the rate of sickness proved very much above the mean for the whole army.

51. "This general assent shows how wrong it is to expect any great and long-continued exercise of force from lads as young as 18 or 20, and the inevitable consequences of taxing them beyond their strength." (Marshall.)

52. *Per contra*: Young men are more easily trained and moulded than older men, especially for the cavalry, and when well led fight as well, as far as mere physical courage goes.

53. But as we cannot keep young soldiers several years in training, and as large bodies of troops will only be raised for sudden war, men not absolutely mature must be rejected.

54. The most effective armies have been those where the youngest men were 22.

55. Should the proposed military apprentices be authorized, there will be no excuse for the enlistment of minors in the line.

Growth and Development.

56. Growth "is the gradual increase to full size by the addition of matter," and development "is the advancement of an organized being from one stage to another towards a more complete state."

57. A man under 22 and especially one under 20 is liable to break down, because physical maturity does not occur until between 23d and 25th years.

The Human Bones and their Development.

58. The adult spine consists of twenty-six superimposed bones (vertebræ), which support the weight of the body and all that can be placed on it.

59. The weakest point is that of the greatest curve, at the "hollow of the back," and the circle of the body, the waist, is least here. Here is most felt the jar of a false step, the fatigue of drills and marches, and the early aching in fevers.

60. The bodies of the vertebræ approach nearly their full size and shape about puberty, but not their complete development.

61. Between 16th aud 18th years five sets of parts to be added (epiphyses) begin to grow from separate centres, and all are not united till 25th or 30th year.

62. The sacrum, which transfers the weight of the trunk to the haunch and lower limbs, consists of separate bones with epiphyseal plates that develop about 15th year and are not united until 26th to 30th.

63. The sacrum and hip bones together form a buttress and arches adapted to support weights, and upon this part men can best support burdens whether in military or civil life.

64. Ribs and all long bones consist of a shaft and epiphyses.

65. The shaft grows from the middle toward the ends. The epiphyses are soft cartilaginous material in the shape of bones, cemented to the bone by a gluey substance, all which gradually harden.

66. Where the ribs hinge on the spine the soft parts commence to turn into bone about 18th and are not completely transformed until the 20th year.

67. The upper part of the breast bone is separate until the 25th; the lower sections unite between 20th and 25th years.

68. The shaft and shoulder-end of the collar bone begin to ossify before any other, but the inner (breast bone) epiphysis appears at 18th and ossifies at 25th year.

69. The shaft of the arm-bone grows until the 25th, but is consolidated about 21st year. The two bones of the forearm are consolidated after the 18th and the hand at the 20th.

70. The haunch is consolidated at the 25th year.

71. Similar conditions are true of the other bones and ossification throughout the skeleton is not complete until 20th-25th years.

72. Other physiological considerations in connection with the young soldier are the growth of the bones and muscles in relation to each other, and the minute internal structural relation of the bony material.

73. The skeleton is designed for locomotion and to enclose and defend important organs of life.

74. The bones are pillars of support and form levers with varied and important movements.

75. The leverage is modified, (1) as the lever is in one or more pieces and is more or less complete in its internal growth, and (2) as the points, ridges and prominences for the attachments of the muscles and tendons are completely or imperfectly grown.

76. The bones become thicker, the joints stronger and the shoulders broader from 20th to 25th years.

77. The muscles gradually develop in strength up to 30th year.

78. The maximum height is barely attained at 25. All the developments increase between 14 and 26, and more slowly with advancing age.

Structure of Bone.

79. Long bones are hollow, with hard dense walls, At the joint extremity the outer surface expands into irregular knobs and bosses, and the inside is filled with a continuous mass of apparently irregular fibres and plates.

80. The short bones are like the ends of long bones.

81. These plates and bars run straight and clear from point to point, cutting each other in true right angles and enclosing clearly defined little square meshes.

82. The tubular structure is the strongest for support, and the strength of bone for tension is of the same order as for pressure.

83.

	Tearing limit.	Crushing limit.	
Cast steel........	102	145	kilogrammes per square millimeter.
Wrought iron....	41	22	
Cast iron........	13	73	
Bone............	9–12	13–16	

84. Bone thus resembles cast steel in proportion of tenacity to crushing, although with much smaller limits.

85. But in the expanded ends, especially in the head of the thigh bone, it curves and overhangs the shaft, so that increasing pressure or crushing force tends to shear it off.

86. When the bone is still immature and the epiphyses still separable, the lines of its fine internal structure are necessarily incomplete along the epiphyseal junction.

87. It is only when the bone is mature that this head is perfected and the lines of fine internal structure are complete and fit to resist the maximum pressure.

88. It is not to be inferred that under ordinary conditions of exercise the epiphyses of a young recruit will become detached, (although under great strain that is possible.) but the difference between bony growth and maturity is illustrated by the foregoing memoranda.

Effect of Pressure upon Contents of Chest.

89. One important function of the skeleton is to enclose and protect the heart and lungs.

90. These organs in the cavity of the chest suffer more in the recruit (of any age) than in the seasoned soldier, and especially in the young.

91. "Next to the inspiration of bad air, the imperfect or continuously obstructed expansion of the chest tends more than any cause we know of to bring about diseases of the heart and lungs." (Aitken.)

92. Pressure before or behind tends to "set" growing bones in an unnatural direction, or to cripple the lungs by confining the chest walls.

93. In the field the soldier must carry packs of some sort, and their pressure especially when ill-adjusted tends to materially derange the contained chest organs.

94. Even canteen and haversack straps may press upon the immature recruit to his harm.

Growth and Development of Heart and Lungs.

95. The greatest amount of the growth of the heart is from 18th to 25th year, but the greatest proportion of growth is about puberty, when it nearly doubles its size.

96. The relative capacity of the two sides of the heart change very materially at different periods: at birth, the right cavities are to the left as 1 : 1½ ; at 30, as 3 : 1

97. The heart doubles its size during the changes known as puberty. If these extend through five years the heart-increase each year is one-fifth ; but if it occurs in one year, the growth is so much more rapid that the heart may become weak out of all proportion to its size.

98. A heart that grows in one year three times as much as in the preceding year is almost necessarily weak. Hence a recruit with a so rapidly developed heart is not acceptable for continuous labor.

99. "The greatest strain is thrown on the heart throughout adolescence to adult age and a very constant group of symptoms indicates the cardiac failure that must be looked for in overworked recruits." (Aitken.)

100. This heart-strain from excessive fatigue in those who have grown rapidly and who have deficient reserve energy is apt to lead to heart failure under unwonted exertion and in emergencies.

101. The lungs also increase in size and weight, especially between the 14th and 25th years, unless crippled by an insufficient bony case.

Effect of Drill upon Recruits.

102. Military drill is intended (1) to instruct the man in certain movements for his greater efficiency as a soldier acting with others, and (2) to develop a certain power of physical endurance.

103. A young recruit cannot keep pace with a full-grown and completely trained man in the ranks, mainly because his heart and blood-vessels are not fully developed nor specially trained.

104. Failure usually arises from attempting too much at the outset; and with excessive work at the beginning, or with a sudden increase as in forced marches, these youths rapidly break down.

105. Drill must begin within the powers of endurance of the recruit, and the young soldier, usually keeping up too long from pride, should be encouraged to fall out of ranks when distressed.

106. "The throb of the heart and the swell of the arteries and veins must be allowed to subside and settle down completely, so that the lungs may resume their peaceful action of easy breathing before any further drill exertion is attempted." (Aitken.)

107. If his breathing does not gradually improve, or if the man's weight continues to decline, he should without further delay be referred to the medical officer for examination.

108. Treatment in such cases cannot be hurried. To take a young soldier into hospital for a week or two only gives temporary ease. No medicine is a substitute for strength, and it may require six months for the heart to recover from one strain.

109. The same symptoms will recur again and again under similar circumstances, until the condition is

outgrown by development maturing, or the heart is permanently damaged.

Influence of Age and Height.

110. But while immature men should not be accepted, neither are too old men good recruits. The authorized limit of 35 (30 for cavalry) is the extreme under ordinary conditions.

111. As long as they are physically sound, recruits are legally acceptable under 35, but unskilled common laborers are liable to become stiffened in body and mentally dulled as they approach 30.

112. It is an important part of a recruiting officer's duty to select critically only those who will probably become strong and active soldiers.

113. The test of mere numbers is a very poor one to determine the efficiency of a recruiting officer.

114. "Nothing is so expensive as an unhealthy military force" (Farr), and "it is of much more importance that a soldier should be strong than that he should be tall." (Vegetius.)

115. Under existing orders very tall men are practically excluded. Were there no regulation, tall *young* men would be objectionable because their height is often gained at the expense of bulk or of the vigor of heart and lungs.

116. A soldier is a machine of two parts, legs and arms offensive, chest and abdomen vital. Within the latter is generated the power that makes the former available.

117. An ill-proportioned tall man is undesirable. If analysis of such an applicant shows that he is tall by virtue of his legs and neck alone, remember that he will become tired sooner; partly because his

muscles are relatively smaller and the levers they operate (the bones) are longer than those of shorter men, and partly because probably less vital force is generated in the smaller organs.

118. That the strongest army is the best army, is a saying as old as the Romans, and properly interpreted it is true. Other things being equal, those with the most endurance are the best soldiers. Certainly the troops that march best are the most efficient.

Particulars as to Recruiting.

119. The recruiting regulations carefully followed are a safe and explicit guide. But there is a constant tendency to disregard their minutiæ, under the feeling that, apart from obscure diseases, any officer accustomed to soldiers can recognize a good recruit at sight.

Therefore, disregarding morbid conditions only discoverable by a physician, special attention is invited to the following points.

120. Should the pulse at either wrist drop a beat at intervals, either before or after exercise, reject.

121. Vision of each eye as tried by test-card must be acute. Each eye in turn should be covered by card-board, not by the hand.

122. Hearing of each ear must easily distinguish ordinary conversation at fifty feet. Unilateral deafness is only distinguishable by carefully closing each ear in succession by pressure, and is disqualifying.

123. The requirements of height, weight, and chest capacity should be carefully observed, because they are based upon physiological laws that cannot be disregarded with impunity.

124. A summary of the general qualifications is:

"A tolerably just proportion between the different parts of the trunk and members, a well-shaped head, thick hair, a countenance expressive of health, with a lively eye, skin not too white, lips red, teeth white and in good condition, voice strong, skin firm, chest well formed, belly lank, organs of generation well developed, limbs muscular, feet arched and of moderate length, hands large."

125. All lank, slight, puny men with contracted figure—men technically termed as of "poor physique" —should be set aside, for there is no class that furnishes so large a proportion to the hospital and the guard-house as this.

126. The utmost care should be had to exclude men likely to be intemperate, for the intolerable nuisance that drunkards are within the service warrants the risk of occasionally rejecting a sober man rather than to accept those who constantly make trouble in peace and who cannot be depended on in war.

127. Flatfootedness, a peculiar dread of many recruiting officers, and thus leading to the occasional rejection of fair men, is rarely seen among the whites of this country.

128. In the disqualifying flat foot, the inner ankle is very prominent and lower than usual; there is a hollow of greater or less extent below the outer ankle; the foot is not well arched, and is broader at the ankle than near the toes; the inner side is flat and occasionally convex, and when placed on the ground the finger cannot be introduced beneath the sole; the weight of the body rests on the inner side of the sole, and the ordinary motions of the ankle are impaired.

129. For bunions, large or recently inflamed, reject. A tightly fitting shoe will at once disqualify with them.

130. Corns on the sole are mischievous, and when under the base of the great toe condemn.

131. Examine the head with the fingers carefully, and for any depression not certainly natural, or for any sensitive spot, reject. Such men invariably break down under exposure to heat or to great fatigue.

132. No precise standard of intelligence can be formulated, but care must be taken to exclude men not capable of appreciating the improved weapons and the more responsible duties of the modern soldier.

133. While all joints must be mobile, special pains should be paid to the right thumb and forefinger which control the hammer and trigger. The strength of the thumb is very important.

134. Sound opposing teeth to chew well the hard food of the field are necessary. At the least there must be two good grinders opposite each other on each side. Unmasticated food leads to sickness.

135. The testicles must be handled, and if either is sensitive or both have dwindled, reject.

136. For enlarged veins of the ankle, behind the knee, or on the thigh, reject.

137. Determine the soundness of the lower limbs by vigorous exercise. Observe keenly that each limb does its full share of work. Count silently the number of hops with each leg in passing twice over a given distance; should they differ, there is weakness or stiffness.

138. A toe, usually the second, sometimes is stiff-

ened at right angles so that the nail touches the ground. Reject, because sand will work under the nail, and cause inflammation. This is known as "hammer toe," or "walking on the nail."

139. Fœtid perspiration of the feet is intolerable in a squad-room.

140. Unsightly markings, leading to rude jests, are disqualifying.

141. The preceding points are those most apt to be overlooked by inexperienced officers, and stress is laid upon their importance in securing sound men.

142. Vaccination as a practical immunity against small-pox should be carefully but not too frequently practised. Thorough vaccination in infancy repeated at the age of 14–16 will generally protect, but every recruit should be presented for examination as soon as he reaches a proper station.

General Considerations.

143. In war, especially under a general enrolment, men with physical blemishes may properly be accepted provided their general health is sound, but every variation from the standard in peace or war should be carefully noted on the descriptive lists.

144. In raising new troops when it is possible to select, for sharp and immediate active service take town-bred men. If a year or two can be had in which to train them, take country-bred men.

145. Open-air military life is physical promotion to city men accustomed to irregular hours, unwholesome meals, and poorly ventilated rooms.

146. To country lads the irregular and sometimes scanty meals, broken rest, necessity for prompt and exact action, and above all the certainty of acquiring

such diseases as measles, whooping-cough and mumps, which town boys always have in childhood, are very exhausting. After a year's training country youths are more valuable.

147. Measles is a particularly serious camp disease, always to be anticipated in newly raised commands, especially ravaging those from the rural districts. In the Civil War there were 67,700 cases with 4,200 deaths among white troops and 8,555 cases with 933 deaths among colored troops in the Union army.

148. The matter of recruiting is thus dwelt upon because it is the foundation upon which the whole military organization rests. It is impossible to have an efficient army without carefully selected men. And after enlistment an equal duty rests upon company officers to see that these men are not injured by their new surroundings.

Comparison between Sickness and Violence.

149. Very little sickness is spontaneous, and with an army of sound men there is no good reason why there should be much loss of duty from disease. When company officers study for themselves the problems of ventilation, of food, of the healthfulness of camps, of water-supply, of the disposal of excreta, when they concern themselves with soldiers as physiological agents, the army will be prepared for the highest exhibition of sustained action.

150. As would be supposed, in peace, when casualties by violence are few, the disability by disease is out of all proportion to that by injury. But in war also deaths from sickness, quite independently of that sickness which is recovered from or which leads to discharge without immediate loss of life, outnumber

many-fold those from battle. Unlike in peace, very many of the disease-causes of war are unavoidable.

151. In the Mexican War, of the regular force 73 officers and 862 men, total 935, were killed or died of wounds, and 85 officers and 4,629 men, total 4,714, died of disease in the field, or rather less than 1 to 5.

Of the volunteers 1,549 officers and men died by violence and 10,986 by disease, or a little less than 1 to 7.

152. During the Rebellion 99,183 white troops died from the casualties of battle and 171,806 from disease, or nearly 1 to 2; while for colored troops it was 3,417 by violence and 29,963 by disease, or 1 to 8.7.

153. The German army in the war of 1870–1 is the only one known to have kept its mortality from disease below that from battle. This probably depended upon the shortness of the war, the rapid succession of battles, the trained troops, and presumably upon its exact discipline being exerted for the care of the men as well as in other directions.

II.

MILITARY CLOTHING.

Its Object.

154. As war tears away the non-essentials but does not supply the deficiencies it exposes, the clothing he is compelled to wear should be suited to a soldier's arduous work.

155. The essential object of all clothing is the protection of the person from extremes of temperature, by conserving bodily heat in cold weather and preventing suffering from either solar heat or that generated by exercise.

156. Soldiers should be dressed as nearly alike as possible, and uniforms have obvious military advantages.

Distinctive Markings.

157. Each arm should be distinguished, as at present, by its appropriate dress, and in large commands the divisions may conveniently be identified by corps badges.

158. Corps badges are devices systematized and attached to the cap: *e.g.*, a Maltese cross, a trefoil, a diamond in cloth, is the device for the corps; then those of the first division would be red, of the second white, of the third blue on a white ground, the fourth orange.

159. They should be inconspicuous to the enemy, but serve both for identification and as a sign of comradeship within the army.

160. There is a constant temptation with new troops to wear some conspicuous mark of regimental significance, whose ultimate effect is to draw fire.

161. Regimental facings are sometimes pressed in the interest of regimental *esprit.* Good results would follow with good troops. But a minor obstacle is that of cost and a serious one that of supply.

In the Crimea the British suffered severely in attempting to keep up the regimental clothing, and until it was abandoned the men were not sufficiently clad.

162. Our State troops will probably long maintain showy dress uniforms for purposes of display. But their fighting clothing, the undress, should be uniform with that of the United States for convenience of administration.

Color.

163. Color is a physiological and a military factor in clothing. Military garments should be neutral in tint. Cadet gray is the best of colors, and next to it a butternut dye, somewhat lighter than the fatigue overalls.

164. Blue will probably always remain the United States uniform, and we can afford to sacrifice some material advantages to patriotic association. But it should be light rather than dark in shade, as is the tendency in the later issues.

165. Colors draw fire in action in proportion to their conspicuousness, red being the most deadly and white the next. Scarlet tells with great effect upon the wearer, and certain zouave regiments certainly left some dead upon the field that would have been saved in a plainer dress. The old-fashioned white cross-belts have had many victims.

166. Dust-gray is the least readily observed of all colors, and the ordinary soil of the field is less marked upon it.

167. Protection against the sun's rays depends entirely upon color, irrespective of texture.

168. Color does not influence bodily heat, nor the external temperature except as directly derived from the sun.

169. White absorbs the least heat, and is therefore the coolest; black the most, and is the warmest; and blue is next to black.

170. Gray, because of its coolness in the sun and its inconspicuousness against nearly every background, is the best military color.

171. The order in which colors draw fire is red, white, black or dark blue, light blue, butternut, dust-gray.

172. The absorption of odor depends partly upon texture in proportion to the hygroscopic power of the material and partly upon color. Black absorbs odors the most, blue next, white least.

173. White canvas overalls, therefore, are a rational dress for men grooming, as against blue woollen.

Materials.

Cotton and Linen.

174. Cotton and linen both conduct heat rapidly, and both are very non-absorbent of water.

175. Bodily exercise generates heat, which ordinarily is reduced by the evaporation of the increased perspiration. When exercise ceases the heat generated is correspondingly reduced, but the perspiration persists for a time.

176. Cotton and linen, allowing the evaporation of this perspiration at a rate that would rapidly chill the body when it remains at rest, therefore are not suitable for *ordinary* military clothing, and are positively dangerous for those liable to violent exertion with abrupt rests.

177. When starched they are nearly as impermeable as wool to air, until perspiration breaks down the starch.

178. Cotton is very cheap, and wears very well.

179. But at extreme southern stations the temperature of the air in the shade for long periods together is above the normal temperature of the body, and slowly enervates the system. It is therefore unreasonable and hurtful to put the soldier under artificial conditions (such as wearing heavy and dark wool) to increase that embarrassment.

180. A thin white cotton tissue worn over a cloth coat will reduce the temperature in the sun's rays 12.6° F.

181. Excellent reports by the medical officer at Ringgold Barracks and by the Medical Director Dept. Texas, 1886, looked to white duck or linen uniform, with light cotton or mixed cotton and wool underclothing, or to a dust-color uniform, one third wool, two thirds cotton.

182. Duck outer-clothing may now (1889) be issued experimentally at some stations, and reports of its use will be received with interest.

183. It may be assumed that while all wool is unreasonably oppressive, an entire cotton dress would be dangerous for men liable to the sudden exertions of military life.

Wool.

184. Wool conducts heat badly, and absorbs water freely in two ways. The water permeates and distends the fibres of the wool (hygroscopic water), and lies between the fibres (water of interposition).

185. In relation to cotton or linen, wool absorbs hygroscopically at least double in proportion to its weight and quadruple in proportion to its surface.

186. Wool, by absorbing the perspiration, counteracts the evaporation that persists after excessive exercise. Dry woollen clothing condenses the vapor from the surface of the body, and gives out much heat that had become latent when the water of the body was vaporized (insensible perspiration).

187. In cotton or linen the perspiration passes directly through, and evaporates on the outer surface.

188. While dry wool is of course better than wet woollen clothing, it is rare that woollen clothes become saturated with bodily moisture; and even when they do, they can be partly dried by wringing, and thus become useful for further condensation and absorption.

189. Wool is not easily penetrated by cold winds, and its quality of non-conduction makes it useful in cold and oppressive in warm climates.

190. The chief disadvantage of woollen clothing, where the climate is suitable, is the difficulty in washing it. Badly washed, it shrinks in the fibre, and the whole after a time becomes smaller, harder, and probably less absorbent. This is the bar to the issue of pure woollen underclothing for the field.

191. The remedy is the admixture of about 30 per cent. of cotton, making the so-called merino.

192. There is some reason to suppose that an all-wool dress acts as a partial preventive against the malarial poison.

193. To wash woollens, they should be placed in hot soap-suds and moved about freely; they should then be plunged in cold water, and when the soap has disappeared should be hung up without wringing. Woollens should never be rubbed nor wrung. (Parkes.) Or: Put the woollens into water by themselves; do not rub soap on them, but have it abundant in the water; move them about freely, for cleansing; rinse them well, without rubbing, in clean water of the same temperature; hang them to dry, without rubbing or wringing, but be careful to stretch them a little while drying.

194. Tests for woollen cloth: When held against the light, it should show a uniform texture, free from holes; folded and suddenly stretched, it should give a clear ringing note; it should resist well when violently stretched; to the touch the texture must be smooth and soft; to the eye it should be close, and free from straggly hair. The heavier it is to the size, the better.

195. Shoddy is old, used, and worked-over wool and cloth. It is often mixed with fresh wool, to the detriment of the latter, and is most easily detected by the tearing power. This adulteration prevails under the greed of war.

196. Serge is a species of worsted that has the advantage of lightness combined with the good qualities of the lesser woollens.

197. Closely woven cloth, whatever the material,

parts with dust more easily than that of loose texture.

Other Materials.

198. Other materials used as auxiliary clothing are leather, canvas, India-rubber and oiled cloth.

199. Leather when properly tanned is practically impervious to the wind, and is very warm; but it is only fit for rainless climates, except as foot-gear.

200. Canvas sheds water, and is an excellent nonconductor of heat, and lined with wool it is admirable against cold.

201. "Slickers," made by thoroughly washing canvas and soaking it with raw oil slowly dried in the sun, are admirable against rain, although not officially recognized.

202. India-rubber has a temporary but invaluable use against rain, but cannot be worn persistently on account of its retaining the bodily heat and the perspiration. It loses its elasticity in very cold climates and becomes too distensible in very warm ones. It ultimately rots by the absorption of oxygen. As a water-proof sheet to place on the ground, it is of great value.

Head Covering.

203. The ideal military hat should protect against heat, cold, rain, and the glare of the sun. It should be attractive on parade, convenient under arms, and useful in bivouac. Such has not yet been adopted. The great variety of hats authorized illustrates the difficulty.

204. The felt helmet, heavy, hot, inflexible, and oppressive, is an imitation of foreign dress, having no

value except for show, and that at great waste of vital force.

205. The white helmet is a comfortable protection against the summer sun; but it is unfit for cold seasons, and is too conspicuous and inflexible for the field.

206. The forage cap protects against neither extreme of climate. With an open-air temperature of 90.2° F., the temperature within the crown of a forage cap worn in the sun was 100.5°, in a black felt hat 98.3°, in an ordinary straw hat 95°, and in a cadet helmet 92.5°.

207. A military cap should always be high enough to clear the crown of the head, and in warm climates ventilation should be provided. Wet muslin in the top of any head-covering guards against sunstroke.

208. The campaign hat as issued is a drab felt, with high crown and broad brim; fairly but not perfectly suited to the field, but not well adapted to garrison.

209. An ordinary sportsman's hat, with high crown, double peak, and folding flaps, as evolved by hunters, would fulfil the requirements of open-air life. Of neutral color, to be decorated to taste. For hot weather it should be of light canvas, and for cold seasons lined.

210. For mere parade purposes, any hat not too uncomfortable, as desired.

Coats.

211. The present dress-coat is closely fitting, warm, and oppressive; it compresses the muscles, and interferes with their action and with the expansion of the chest in direct proportion to the pressure. It is the most unhygienic and therefore unmilitary article of

a soldier's apparel, because it directly antagonizes the vigorous exertion he must make in the field, and to which all his training is supposed to be directed. The practical evidence of this is its invariable abandonment when the field is taken.

The dress-coat is merely a costly and hurtful agent of display.

212. The present undress coat is a loose, fairly-fitting flannel sack, with pockets in the breast and the side skirts. When sufficiently loose it is not conspicuously bad, but it is unsightly when the belt is worn.

213. The hunting shirt, to which in some form all woodsmen and frontiersmen come, is the natural and typical military dress, and by slow degrees the working dress of the army is approaching it.

214. The ideal military blouse should follow the figure loosely, with yokes and gores; be large in the shoulder and arm for unconstrained exertion, and small at the wrist; full in the body for abundant underclothing and free motion; to have a belt between the body and skirt upon which the waist belt should fit, and should be held together in front by an inner belt with graduated fastenings; to have stout pockets in the body and skirt; skirt just short enough to clear the ground when kneeling to fire. It should be made of closely-milled light woollen cloth, or a good grade of navy flannel.

215. The general and only objection made to such a dress is to call it slouchy. But no man held in position by his clothes is either very vigorous or soldierly. Setting up, not tight clothing, makes the martial figure.

Shirts.

216. A knit woollen undershirt, which sometimes is unbearable by delicate skins, and formerly, at least, was too short, is issued. The later issues are better.

217. It should be one third cotton for ordinary issue, and in three grades of thickness. A soldier should be allowed to draw two sizes, to wear one over the other if necessary. In hot climates this should be two-thirds cotton.

218. Overshirts of flannel of various patterns have lately been issued tentatively. The best has a rolling collar and breast pockets, is reasonably full, and may be worn without the coat on fatigue. It approaches the hunting shirt, and is comfortable and useful. These should be issued in three grades and many sizes with and without collars, for two or more to be worn together.

219. Animal heat is best conserved by several superimposed similar garments, taking advantage of the contained layers of air which are poor conductors. This is the custom of lumbermen and ice-cutters, who discard overcoats while working.

220. The chief utility of overcoats is against storms, and when not much independent motion of the limbs is required.

221. Color has no influence upon animal heat, but dark colors absorb animal odors; hence undershirts should be light. All shirts should be long enough after washing to fully protect the abdomen.

222. In the field an extra shirt, for wearing next the body, should always be carried, and the two shirts may be worn alternately. At the close of the day's work the worn shirt should be taken off, dried,

stretched, well beaten, and hung in the wind and sun. This should be done even when there is no change.

223. The combination of perspiration and dust is very disagreeable and hurtful, and drawers, stockings, and trousers should be treated as the shirts.

224. The persons and underclothing of men should be carefully inspected for cleanliness, in garrison and in camp.

225. Dirty troops are always sickly troops, and men with clean shirts in their knapsacks at inspection may wear soiled clothes and have dirty skins.

Trousers.

226. Trousers should be large over the lower pelvis; snug over the upper hips, with broad inner belt for secondary support; no suspenders; ample pockets; narrow and pliable bottoms, or cut so that they may be narrow or full at pleasure. In practice stockings are drawn over the trousers' bottoms in mud and dust.

Gaiters.

227. Gaiters or leggings are of doubtful utility. All additional articles are objectionable as such; when tight enough to remain in place, these are liable to be too tight, and to cause the feet and ankles to swell; cotton and light canvas wrinkle into bands, and light leather becomes harsh after wetting. Excellent under special conditions, but objectionable as a regular supply.

Drawers.

228. Drawers are primarily for cleanliness, secondarily for warmth. As now issued, the soldier is

tempted to discard them in hot weather, to his ultimate discomfort and occasional risk of health. They should be of three grades and many sizes, and cut as proposed for trousers.

Stockings.

229. Stockings are now issued in woollen and cotton. Woollen stockings frequently cause free perspiration even in winter, when by the retention of moisture the feet are chilled.

230. Wet feet may be uncomfortable, but are rarely harmful to a man in good health who is taking active exercise. It is when he allows himself to be chilled that he takes cold. But to be sedentary with wet feet may be dangerous.

231. A wet skin or wet feet under extreme cold are dangerous. An experienced man who has broken through the ice in the bitter weather of the northwest will not attempt to proceed until he has dried himself and his clothes, stripping if necessary to do it, and making if possible some sort of fire.

Shoes and Boots.

232. Campaigns are won by marching, and soldiers cannot march with crippled feet. Even in the cavalry a large part of the duty is performed on foot, and boots and shoes are potent to preserve or damage those important members.

233. A good shoe should have a thick, wide sole, to project beyond the upper leather; a low, broad heel; no seams to press upon the skin; when sewed, thread well waxed and stitches numerous; should allow one tenth in length and more in breadth for the expansion of the foot; should be large enough across the

instep, but nowhere too large nor with rough inner seams, lest the folds made in fastening chafe, and the friction of the moving shoe blister.

234. A common error is an excess of leather in front of and a deficiency over the instep.

235. The present shoe can probably be improved by making it high enough to embrace the ankle and wide enough to enclose the trousers' leg when desired, with a slit and tongue in front over which the sides may lace, like the Thompson hunting-shoe.

236. The most constant and careful supervision is necessary to prevent men wearing unauthorized shoes, which are very liable to injure their feet marching.

237. Good shoes will last about two months constantly marching over reasonably rough roads, and much longer under more favorable conditions. But only brass-screwed or hob-nailed soles will withstand marching in climate and soil like those of Arizona.

238. Boots suited for the saddle are apt to chafe in walking, and cavalry should carry shoes for dismounted and camp duty.

239. To substitute for the boot a shoe with a heavy detachable leg and stiff brace for mounted service, would probably add to the comfort and the efficiency of cavalry.

240. Campaign shoes weigh 2¾ lbs. a pair, and the extra pair required to be carried is a heavy tax for infantry to bear. The barrack shoe, or a similar water-proof shoe, might be taken for the camp; and men should be taught to cobble and to apply glued patches.

241. Boots and shoes in the field should be carefully water-proofed, for which Parkes gives these practical directions: Dissolve half a pound of shoemakers'

dubbing carefully with gentle heat in half a pint each of linseed-oil and solution of India-rubber. As this is very combustible, great care must be taken. It should be rubbed into the boots, and be renewed about once in three months. The solution of India-rubber is in ether, which evaporates easily, and is extremely inflammable.

242. Good marching is the complement and sometimes the equivalent of good fighting; and careful inspection of the feet and instruction as to their care are necessary, especially with raw troops.

243. An infantry officer should be as solicitous as to the care of his men's feet as a cavalry officer is of his horses', and should pay close personal attention to them.

244. When unaccustomed to marching, the feet should be well soaped or greased before starting, to prevent chafing. At the end of the march they should be washed or wiped very clean and dry, for which a very little water is sufficient. The feet may be toughened by soaking in a strong tepid solution of alum when practicable.

245. A blister should be opened by a small hole at the lowest point, allowing the fluid to drain. The skin should not be torn. For positively sore feet the man should promptly report sick, which will shorten the disability and relieve the intense misery.

246. The German army is said to use successfully this powder for the prevention of sore feet: Salicylic acid three parts, starch ten parts, pulverized soapstone eighty-seven parts, each by weight. It is sifted in the shoes and stockings to keep the feet dry, to prevent chafing, and to heal sore spots.

Other Articles of Clothing.

247. The blankets and overcoats are excellent, and it is doubtful whether they can be improved upon except by lining the latter for cold stations.

248. The canvas over-suits are very useful parts of the clothing allowance, and there are many occasions when they might with great advantage be taken into the field.

249. The special articles, such as hoods, gloves, over-shoes, and overcoats of extra warmth, now issued for protection against very severe weather, are fully justified by the causes leading to their introduction and the results following their use.

250. Formerly 15 per cent. of exposed garrisons were off duty several weeks each winter from frost-bite, not to speak of inability to take the field. Now frost-bite on duty in men thus protected is very rare.

251. Abdominal protectors, small aprons made of two thicknesses of flannel sewed or quilted together and worn next the skin over the bowels, materially lessen those bowel affections that depend upon abrupt changes of temperature. These are not issued, but there is no reason why they should not be in sub-tropical climates and elsewhere on occasion.

252. Ponchoes and water-proof blankets admirably protect against rain or ground-moisture. When lying upon one on damp ground a man is spared very much risk, but he will not be protected from the subjacent cold by the water-proof alone.

253. Men should be encouraged to mend their own clothing, independently of craftsmen. A little systematic instruction in sewing would be labor well expended.

254. The subject of clothes deserves careful and constant attention by officers serving with troops. Administrative officers in the central bureaux must depend in great part upon the reports of company officers as to the results reached and the deficiencies to be corrected. But such reports should be made after well-considered study, for thoughtless complaint and immature advice are worse than none.

III.

FOOD.

255. "Force manifested in the living body must be the correlative expression of force previously latent in the food eaten or the tissue formed." That is, a soldier's food must be adequate to repair the ordinary wear and tear and, if unfortunately he is yet a growing lad, to supply additional tissue.

256. Food supplies energy and animal heat, partly directly and partly by replacing expended tissue.

257. There are five general classes of food, viz.: The albuminates (flesh); the hydrocarbons (fats); the carbohydrates (starch and sugar); the salts; and water. In one sense the air also may be called a food. These are combined in two groups, the nitrogenous and the non-nitrogenous.

258. The nitrogenous substances are necessary in the manifestations of energy.

259. "Every structure in the body in which any form of energy is manifested, as heat, mechanical motion, chemical or electrical action, is nitrogenous." (Parkes.)

260. The presence of nitrogen controls the absorption of oxygen from the atmosphere. "The absorption of oxygen does not determine the changes in the tissues, but the changes in the tissues determine the absorption of oxygen." (Parkes.)

261. Life is really a form of motion; the moment a tissue or a body is microscopically at rest, it is dead.

262. The albuminates, or albuminoids, receive their

class name from their most marked ingredient—albumen. Albumen is a complex substance, chiefly remarkable for the presence of nitrogen (N) and of a little sulphur (S). Its formula is $O_{21}H_7N_{15}C_{53}S$.

263. The albuminates are found in the flesh and blood of animals, in milk as casein, in seeds—especially in legumes, and in a certain proportion in the gluten of wheat and in other cereals.

264. The various albuminates are not identical, but are similar, and viewed as food their value rests upon their contained N.

265. The starches and sugars are generally grouped together as carbohydrates.

266. Starch, $C_6H_{10}O_5$, is found in all cereals, especially in wheat, oats, maize, barley, and rye; in the legumes or pulses; in rice, buckwheat, etc.; in the potato; in carrots, parsnips, and turnips.

267. Under the action of saliva in the process of digestion, and by the aid of cookery, starch is converted into dextrine of identical chemical composition and into grape-sugar or glucose, $C_6H_{12}O_6H_2O$.

268. Cane-sugar, $C_{12}H_{12}O_{11}$, is also converted into grape-sugar early in the process of digestion, and in the liver it is transformed into glycogen or animal starch, $C_6H_{10}O_5$. This is stored up in the body, to be called on as needed.

269. The surplusage of grape-sugar goes to make fat, and that sweets are fattening is notorious.

270. The hydrocarbons, generally known as the fats, contain much more H and C and much less O than the carbohydrates. The formula is $C_{10}H_{18}O$.

271. The physiology of fat and of its digestion is yet very obscure, and only the rudiments of the current belief about it follow.

272. The hydrocarbons are derived from the fats and oils of commerce, but as stored in the body the fat is chiefly derived from the carbohydrates. There is no present proof that fat is stored in the body as fat.

273. Fat taken as food is broken up in fine particles in the intestines and there absorbed. It is believed that part of it is taken up in the tissues and the rest is burnt as fuel. Fat seems essential to all growth, and hence especially necessary to growing youth.

274. Fat as fat is generally objectionable to the stomach in health, and its grosser forms are apt to disgust the appetite. But the wise instincts of nature allow much more of the animal fats to be eaten in cold than in warm climates.

275. But in the warmer latitudes the vegetable oils are freely consumed.

276. The main point to be remembered is that both carbohydrates (sugars and starches) and hydrocarbons (fats and oils) are necessary parts of human diet.

277. The inorganic salts are chiefly chlorides and phosphates, compounds of calcium, potassium, and sodium, not great in amount, but important, and generally supplied in composition with the ordinary alimentary substances.

278. The value of common salt ($NaCl$) is notorious. It is found in every tissue except the enamel of the teeth, it assists digestion, and in part regulates the passage of fluids through the denser tissues.

279. Lime helps to make bone, and potassium to make blood and muscle.

280. The vegetable salts, the lactates, tartrates,

citrates, and acetates, become carbonates in the blood. These are peculiarly important, because scurvy appears in their absence.

281. The acids from which these salts are derived exist chiefly in fresh vegetables. Their nutritive value is small, but it is a well-known principle of dietetics that they must be supplied.

282. Water is not strictly a food, inasmuch as "it undergoes no change, no chemical alteration, in the body, and hence is not susceptible of liberating force. But it contributes to chemical change by supplying a necessary condition for its occurrence in other bodies."

283. Water makes the solution of the food necessary for digestion; the tissues are bathed in fluid, and our secretions and excretions in great part escape in water.

It carries the solid infinitesimal tissue-making particles all through the body, and bears away excrementitious matter.

284. A man dies of thirst sooner than of hunger, and the wounded require water to supply an essential element in the escaping blood.

285. Water also has a peculiar hygienic value as one of the most common avenues for the introduction of serious disease.

286. The practical point to determine is what food is necessary for the repair of waste in soldiers, and how it is to be supplied.

287. The salts, being generally found in sufficient quantities in ordinary alimentary substances, need not be considered.

288. On the fundamental principle that it is the province of food to supply energy and animal heat,

the general proposition is that C and N represent the required materials, and that man needs about fifteen times as much C as N.

289. Practically the albuminates are the chief sources of the nitrogen, and the fats, starches, and sugars supply the carbon ; but almost every food contains both elements.

Thus, starchy food does not contain starch alone, but it is chiefly starch.

290. The problem of all diets is to secure the proper proportion of each class and form of food at a practicable cost, and to utilize it without undue strain upon the animal economy.

291. Confining a man to a meat diet would require him to absorb four times as much nitrogen as necessary in order to get sufficient carbon; or a bread diet would overload him with carbon before he received enough nitrogen.

292. To supply the desirable N and C by one kind of food alone would require 6½ lbs. of flesh, or 4½ lbs. of bread, or 15 lbs. of potatoes a day, and this at the risk of disease from the surplus, supposing the whole to be digested.

293. The albumen of flesh must therefore be supplemented by fats, starches, sugars, organic acids, salts, etc., and bread requires flesh, fat, etc.

294. All food contains water in mechanical combination, which is disregarded in calculating the nutritive value.

Therefore in determining the amount of real food, allowance must be made for the contained water as about 50 per cent. additional.

295. Parkes makes this estimate of the daily water-free food necessary for a soldier:

	Ounces. Garrison.	Field.
Albuminates (flesh)	4.31	6–7
Hydrocarbons (fats)	3.53	3.5–4.5
Carbohydrates (starches and sugars)	11 71	16–18
Salts	1.10	1.2–1.5
	20.65	26.7–31

For other tables see par. 471 *et seq.*

296. Besides the solids, from 3 to 5 pints of liquids are taken daily.

297. But under conditions of enforced inactivity, and especially where privation compels, life may be sustained on much less than the standard.

Thus, at the siege of Paris inactive persons subsisted on 1 oz. meat and 10 oz. bread per diem.

298. Col. Perrin, Medical Department, has determined that, making every possible combination of the ration, the issue is lacking in some particular for garrison use, and that in all but the issue of salt pork for beef, and hard bread for soft bread, it was below the standard for the field. As pork is frequently unavailable for marching troops, the ration, however combined, is theoretically insufficient.

299. Garrison life really corresponds with the "life of activity" of the physiologists, and the best combination, viz., $\frac{2}{3}$ beef and $\frac{1}{3}$ bacon, hard bread, beans and coffee = 25.82 oz., and is 3.37 oz. below what is required.

300. In practice the deficiency is made up by not using all the bacon, sugar, coffee, soap, candles, and vinegar, and with the savings purchasing flour and other articles; by adding produce from the gardens, occasionally by hunting, fishing, etc., and by contributions from the men.

301. Very recently (1889) the abolition of the post

fund has made it possible to increase the bread ration and to have more money available for the purchase of extra food, to the greater comfort and advantage of the men.

302. The idea that the ration is in excess receives color from the excess of fats and salts in the bacon, and from the possibility of the sale of part of it when all bacon is issued.

303. Sugar and coffee should be saved only when the albuminates are so low as to require their transmutation into nitrogenous food.

304. The consumption of the regulation ration in garrison is so variable owing to barter, sale and purchase, cultivation, etc., that it is useless to attempt to judge of its fitness in one place from its suitability to another.

305. In the field, where it is most important, it is least elastic and no back rations are issued.

306. Practically the question is: Are the bread and the meat sufficient?

307. The standard bread ration is 18 oz., but during a part of the Civil War it was increased to 22 oz. soft bread or flour, and to 100 rations 30 lbs. of potatoes, or 4.8 oz. per ration, were issued.

308. Some years ago an investigation into food actually consumed during periods of ten days by eighteen companies, six officers, and one gang of thirty-eight quartermaster's men, all in the Division of the Pacific, gave these results:

(1.) There was a marked excess in the amount consumed over that supplied by the Government.

(2.) The average excess consumed over issues by Subsistence Department plus purchases by Company

Fund was $12\frac{1}{4}$ oz., of which nearly 12 oz. was vegetables.

309. One company at Fort Apache consumed about 11 oz. meat, $10\frac{1}{2}$ vegetables, 25 bread.

One at Fort Mojave $10\frac{1}{2}$ meat, 11 vegetables, 28 bread.

One at Fort Gaston 10 meat, 32 vegetables, 17 bread.

One at Fort Halleck 14 meat, 36 vegetables, 17 bread.

Six companies at Presidio, San Francisco, 9 meat, 24 vegetables, 21 bread.

38 Q. M. men in one mess, Presidio, 17 meat, 24 vegetables, 17 bread.

These quantities represent what was actually eaten, bones, husks, crusts, etc., being deducted from what was placed on the table.

310. Medical officers of experience have advised that an adequate ration should consist as follows, in comparison with the present allowance:

	Proposed. oz.	Now. oz.
Fresh beef or other fresh meat	20	20
or Salt beef	20	22
or Pork or bacon	12	12
Flour	22	18
or Soft bread	22	18
Except on fatigue, when		
Flour or soft bread	24	—
or Hard bread	16	16
and Flour	4.8	—
or Corn meal	24	20
Beans or pease	2.4	2.4
or Money value in milk, fresh or canned, or cheese if possible.		
Potatoes 60 lbs. to 100 rations	9.6	—

311½. Act of June 16, 1890, adds 1 lb. vegetables to the ration. G. O. 78, July 25, 1890, issues 100 per cent. fresh potatoes, or 80 per cent. fresh potatoes and 20 per cent. fresh onions, or 70 per cent. fresh potatoes and 30 per cent. canned tomatoes or other vegetables.

No savings of these purchased by Subsistence Department.

	Proposed. oz.	Now. oz.
or Otherwise, money value in fresh or dried fruit,		
Rice	1.6	1.6
or Value in fresh vegetables,		
Sugar	2.4	2.4
Coffee, green	1.6	1.6
or " roasted	1.28	1.28
or Tea	.24	.32
and Candles, soap, pepper, etc.		

311. The foregoing table gives an excess of 1.865 oz. water-free food over the average physiological requirements, with which to obtain a necessary variety.

312. The ration of beef is estimated on the basis of the raw issue. There is a waste of 5 per cent. in cutting up the carcass. A fair proportion of bone in beef is 20 per cent. In cooking, meat shrinks about 25 per cent. in weight.

313. When the quality of beef is good, the issue is sufficient.

It is insufficient when taken from tough Texas cattle, or when issued in the spring from frozen carcasses slaughtered in the autumn.

In cooking frozen meat the loss is believed to be 10 per cent. more than with fresh meat.

314. The proportion of fore-quarters to hind-quarters is about 8 to 7.

315. Beef for issue should be well grown and nourished, and cattle are best about 4 years old. Steers should weigh about 1000 pounds.

316. The weight is best determined by putting average samples on the scales. Sixty per cent. of the live weight is the average net weight.

317. When weighing is impracticable, use this formula:

$$(C^2 \times .08) \times L \times 42 = W \text{ (net)}.$$

$C =$ girth behind shoulder-blades; $L =$ length from front of shoulder-blades to root of tail; 42 lbs. = cubic foot of flesh. $W =$ weight. ($C =$ circ.; $.08 = .07958$; $C^2 \times .08 =$ contents.)

Or, $$C^2 \times 5L \div 1.5 = W.$$

If fat, divide by 1.425; if lean, by 1.575.

318. In temperate climates beef should be killed 24–36 hours before issue. In hot climates, 8–10 hours.

319. Good beef should have about 20 per cent. bone; the fat should be firm and sufficient, but not in excess; and the flesh firm, elastic, and marbled from little veins running through it.

320. From good meat placed on a white plate a little reddish fluid will be found to exude. This is not a bad indication, as it is sometimes thought to be.

321. The flesh of young animals is pale and moist, and that of old animals is dark.

A deep purple indicates that the animal has died with the blood in it.

Blood is objectionable, not because it is unhealthy in itself but because it decomposes very rapidly.

322. None of the meat should be livid, and the interior should be the same color or a little paler than the surface.

There should be no softening nor fluid within the tissues. In commencing putrefaction the color is first paler and later greenish, and the odor disagreeable.

To Cook Meat.

Boiling.

323. For boiling, the pieces (of any meat) should be as large as possible, and be plunged into boiling water to coagulate the albumen in the exterior layer, and thus retain the inner juices.

324. After 5 or 10 minutes the water should be reduced to 160° F. Above 170° the meat becomes hard and indigestible. Albumen becomes stringy at 134° and coagulates at 160°, but of course the interior of a large piece of meat is cooler than the surface or than the water.

325. Soldier cooks generally use excessive heat, and company inspecting officers should check them with the assistance of the kitchen thermometer.

326. Meat is more effectually cooked at this lower temperature than by boiling.

327. Simmering and boiling are the same. The water should not simmer, but remain at 160°–170° F. fifteen minutes for each pound of meat. Hence so-called boiled meat is not boiled—or should not be.

328. That actual boiling is not necessary, is illustrated by the fact that meat "boiled" at Fort Lewis or at Denver, and that at the seaside, are practically the same, although at the higher elevation the boiling temperature is lower.

Water boils at $\left\{ \begin{matrix} 1^\circ \text{ F.} \\ 1^\circ \text{ C.} \end{matrix} \right\}$ less for $\left\{ \begin{matrix} 600 \\ 1080 \end{matrix} \right\}$ ft. of elevation owing to diminished pressure.

Roasting, Baking, Frying, and Stewing.

329. The so-called roasting is baking; but meat may be roasted by cutting it into pieces, 1–2 in. sq.,

and holding it for a few minutes before a hot fire, as in the field.

330. In baking, first apply an intense heat to coagulate the outer albumen and then reduce the temperature.

331. To fry, is to boil in fat, which would be excellent, but is never done.

332. Slowly heated, fat evolves fatty acids, generally injurious, penetrating the particles of frying food and enveloping them in grease.

The gastric juice cannot dissolve this and it is an irritant in the stomach.

333. To fry properly the fat should appear to boil. The temperature known as "boiling hot" is shown by little jets of smoke, not steam, from the surface.

Fat cannot boil under ordinary atmospheric pressure, although a fatty acid of butter, butyric, may do so. The appearance of boiling, the sputtering, is due to water in the lard.

334. Food cooked in fat should be drained for a a few minutes in a seive.

335. To stew meat, small pieces should be kept for about two hours at a moderate heat (134° + F.) in a little water.

The object is to partly extract the juices, keeping the albumen semi-fluid and retaining all the surrounding liquid.

336. That very high temperatures are unnecessary in cooking meat, the Norwegian stove (as modified, Warren's cooker,) shows:

In its simplest form this is a wooden box thickly lined with felt. In the middle is a stew-pan with a felt lid. The contents are heated as desired, the pan is placed in the box which is covered, and left to

itself. In a few hours the work is done without the need of more fire.

337. The chemist's water-bath, of which a glue-pot is the type, is an excellent cooking apparatus and might well be used in all garrison kitchens.

Soup-making.

338. To make soup, put uncooked meat into cold water, (1 lb. lean meat to 1 qt. water,) heat gradually and cook slowly. Rapid boiling drives off the aroma and probably part of the nutritious matter.

Cracked bones by their dissolving marrow add to its strength; cooked meat may be added to soup three-quarters of an hour after putting on the fire. Vegetables, except potatoes, one hour and a half before it is done; potatoes, 30 minutes. The more fragments of cooked or uncooked meat and broken bones the better.

339. A scrupulously clean pot, slow cooking and constant skimming are the essentials of soup-making.

Salt Beef.

340. The ration of salt beef is 22 ounces.

The nutritive value of salt beef may be reckoned at two-thirds that of fresh, decreasing by age.

341. Meat is salted to preserve it, but this is at the expense of some nutritive matters that pass into the brine.

342. From brine in which beef has been salted, about half a pound of flesh extract to the gallon may be taken by dialysis. But brine several times used becomes poisonous, by the decomposition of the contained animal substances.

Fresh Pork.

343. Fresh pork, never issued, is sometimes obtained through the company fund or otherwise. This and veal are liable to cause diarrhœa, especially in those not accustomed to them.

Both, and especially pork, should be well cooked.

Salt Pork.

344. Salt pork contains much more N and C than fresh pork and is issued at 12 ounces to the ration.

345. Salt pork and salt beef are carried with difficulty in the field, and are not very acceptable. When cooked hard and dry they are tough and insipid. Much nutritive principle passes into the brine, leaving only a fictitious nitrogenous value to the solids.

Bacon.

346. Bacon, containing much more N and C than fresh pork, is issued at 12 ounces to the ration.

347. Bacon is the exception to the rule that cured meats are less digestible than fresh. Its fat is more acceptable than pork, it is easily transported and is well suited to the wants of severe exercise.

348. But bacon is not acceptable to those not in rude physical health, and to most men in hot climates, except as an occasional diet; and sometimes it wastes as much as 20–25 per cent. under natural heat. Bacon slop-fed and summer-cured wastes much more rapidly than that corn-fed and winter-cured.

349. Notwithstanding its waste under heat, properly selected bacon should generally be substituted for salt pork at southern posts. It should be stored in bins with bulk salt in alternate layers.

350. Bacon with very deep layers of fat and thin

layers of lean should only be issued at northern stations, for it can neither be cooked properly in the field nor eaten with satisfaction at the south. The weight of the sides determines the proportion of fat. Sides weighing from 25 to 50 lbs. are preferable.

351. When the fat of bacon is yellow and the taste is strong, the meat is rusty or tainted; when the lean has brown or black spots, it is not good.

Bacon from stag hogs or those fed on mast may be yellowish and still be good.

Corned Beef.

352. Cooked corned beef in cans at 12 oz. is a substitutive part of the ration where cooking is impracticable.

It has double the nutritive quality of the same quantity of uncooked beef, and will probably play an important part in future wars.

353. It contains 60 per cent. solids, of which 40 are albuminoids, 15 fat and 5 salts. Nitrogen is 6 per cent. of the whole.

354. Corning is treating raw beef to a pickle, for which this is a good formula:

To 50 lbs. beef take 2 gals. water, 4 lbs. salt, 1½ lbs. brown sugar, 1½ oz. salt-petre, ½ oz. saleratus. Boil, skim and cool gradually. When cold put the beef in the brine under a weight. It may be used in 8 or 10 days. This is to be boiled.

After the brine has been used four times it must be boiled and skimmed. This may be repeated three times.

Diseased Meat.

355. "Bad," that is decomposing, meat should not

be eaten; but meat from animals suffering under severe and mortal diseases may be consumed without harm. While such food ordinarily should be condemned, in severe straits it is better to issue it than to allow troops to starve.

356. Animals ill and dead of the cattle plague (rinderpest) and of epidemic pleuro-pneumonia have been eaten repeatedly without harm, and as late as 1871 horses dead of glanders and farcy were consumed in large numbers at the seige of Paris.

357. But it is essential that such meat be thoroughly cooked, and it is much safer that all the blood be carefully drained and not used.

358. But tuberculous (consumptive) meat may infect the consumer, and milk from such cows is dangerous.

359. Ordinarily, animals affected with malignant pustule should be burned, not buried.

360. But while all diseased animals are not necessarily to be condemned as food, persons have been poisoned by the stronger medicines with which they have been treated.

361. Besides consumption, beef and pork when imperfectly cooked may communicate tape-worm, and pork the trichina to man.

362. The measle of the hog and of the ox is a worm that when swallowed generates tape-worm in man.

363. The measle (cysticercus-ci) is a small round body observable with the naked eye, and when numerous the flesh crackles on cutting.

To speak of old and rusty pork as "measly" is incorrect.

364. Trichina spiralis when swallowed by man results in a highly painful and dangerous disease.

365. All doubtful meat should be thoroughly cooked.

Trichinæ are killed when albumen is coagulated (160° + F.). But if the interior of boiled or roasted pork shows the color of uncooked meat, this has not been attained. Trichinæ are also killed by hot, not common smoking.

366. Sausages and pies from meat apparently wholesome become poisonous by the formation of a yet unknown substance. Age is presumed to be one of the factors.

367. In warm weather, hash, prepared the night before it is to be eaten, and stale mixed dishes are liable to induce colic and diarrhœa.

368. Meat may be preserved for some time by heating very strongly the outside, thus coagulating the albumen in the outer layers and hermetically sealing the interior.

369. The application of charcoal or sugar to the surface is preservative, and gunpowder rubbed into the surface would probably have a similar effect.

370. In cooking vegetables there is a shrinkage of about 10 per cent., exclusive of waste.

Bread.

371. Bread, the other important part of the ration with meat,—for practically bread and meat make up its value,—is the only portion of it in which there is no waste.

372. Bread is not a complete diet, being deficient in fat and moderately in N; hence butter or other greasy food is eaten with it by instinct. But it is one of the few foods that never pall upon the appetite.

373. In making bread there is a gain in weight of

about one-third over the flour actually used. Formerly this difference between an 18-oz. ration of flour and an 18-oz. ration of bread was practically lost to the soldier as food, the difficulties in the way of increasing the bread ration being insurmountable except under peculiar circumstances.

374. But under very recent regulations the bread ration may be increased to the limit of the flour ration, by the concurrent action of the council of administration and the commanding officer.

375. The weight of the bread ration is to be taken cold, bread losing weight after baking.

376. Dough is flour mixed with salt and water.

Bread is dough distended through its particles with CO_2 and cooked.

377. Flour is the crushed kernel of wheat with the two outer husks removed.

378. Flour contains 9–14 per cent. N, chiefly in the gluten, and 60–70 parts carbonaceous matter (starch, dextrine, sugar).

379. The husks or bran contain about 15 per cent. N, 3.5 fat and 5.7 salts. Although theoretically nutritious, it is not so practically from its indigestibility.

"Whole flour" is of doubtful utility, because of the mechanical irritation of the bran.

380. "High patent" flour is classed as the finest, but moderately dressed or "straight" flour is the best for issue.

381. "Straight" flour is the whole product of the wheat less the refuse, with a small percentage of low grades. A bushel of wheat (60 lbs.) should yield about 44 lbs. of this flour.

382. "Family" flour is generally a high patent,

sharp and well milled from selected wheat, and thus of higher price.

383. Flour is tested by touch, color, taste, odor, and strength or elasticity.

384. Formerly absolute smoothness and whiteness were signs of the best quality; but the roller process by which most flour is now made does not yield an impalpable powder but one slightly rough, and the dark color of the hard winter wheat ("Russian" and "Turkey") gives that flour a marked yellow tinge.

385. Nevertheless decided grittiness or excessive yellowness indicates, as formerly, commencing change.

386. Whatever the standard, flour must be uniform in color. Specks show imperfect milling or very low grade.

387. Dry roller process flour is not as adhesive as buhr-stone flour.

388. Good flour is slightly acid to test paper, but not to the taste. Recognizable acidity indicates change. Acid flour makes sour bread.

389. A disagreeable taste, or musty or sour odors, indicate bad flour.

390. Boiling water poured on a handful of flour should evolve no odor other than that of freshly-ground wheat.

391. The relative strength and elasticity of the gluten make a standard for comparison between different qualities of flour by the dough test.

392. *Dough Test.* Mix carefully flour 2 oz., water 1 oz.; when the flour is all incorporated, shape the mass into a cylinder $1\frac{3}{4}$ inches in diameter by $2\frac{3}{4}$ inches high, standing on its base; after 30 minutes it is evidence of strength if it has stood up well with a

hardened dry surface; if it falls, flattens, or runs over the plate, it is a sign of weakness, of inferior milling, or of poor stock. Knead it again carefully, flatten it and pull it out gently, not suddenly, for about 5 inches; should it rebound quickly, it is evidence of strength and superior gluten. Again knead it gently, flatten it out uniformly to the size of a plate, gently and gradually pull it at the edges until it is very thin, like distended rubber; if this can be done without tearing, it shows strength and superior gluten.

393. Failure of the dough test shows weak flour from poor wheat, sprouted, damaged, or old, or imperfect milling and defective gluten.

394. Flour absorbs odors readily, hence it should never be stored near vegetables, fruits, spices, tobacco, turpentine, coal oil, etc.

395. Flour sacks should be piled about nine high, with the tiers six inches apart, in a dry room.

396. In making bread, the temperature to which the dough is raised coagulates the albumen and transforms part of the starch into dextrine, and a certain amount of sugar and CO_2 are formed.

397. Bread may be made in three ways:

(1.) By generating CO_2 by yeast or other ferment added to dough;

(2.) By mixing sodium or ammonium carbonate with the dough and adding hydrochloric, tartaric, phosphoric, or citric acids (baking powders);

(3.) By forcing CO_2 through the dough (aerated bread).

The third is probably the best method, because the conversion of starch into dextrine, sugar and lactic acid is limited, but it requires special apparatus.

398. A good baking powder is: Tartaric acid, 2 oz.;

bicarbonate of soda and arrowroot each 3 oz.; all well mixed and kept perfectly dry in a wide-mouthed bottle. (Yeo.)

399. The first is the ordinary garrison method: For 20 lbs. flour, take 8–12 lbs. tepid water, 4 oz. yeast, with a little potato and 1½–2 oz. salt.

The baker's skill checks the fermentation at the proper point.

400. A little alum is empirically added in making bread, its action being uncertain. Some suppose it limits excessive changes, others that it aids in the formation of CO_2.

401. Alum whitens bread and utilizes some flour that otherwise could not be used. In the small quantities in which it is legitimately used, it is harmless. Alum in excess, as in some baking powders, delays digestion.

402. Bread is heavy from bad yeast fermenting too rapidly, or when it has not fermented enough, or when too much or too little heat is used.

It is bitter from bitter yeast.

It moulds rapidly from an excess of water.

403. If acid flour must be used, lime-water (from quick-lime) is required.

404. Yeast is the ordinary ferment.

405. Leaven is ordinary dough kept moderately warm for some time, of which a lump undergoing fermentation is kneaded into fresh flour and water and made to permeate the whole.

406. Occasionally flour is found that is poor in quality. Flour from sandy soil or where lime is deficient may rise well enough, but becomes heavy and sour as it cools. The same condition may follow

the use of yeast from too old stock. Good bread may be made with such flour by using lime-water.

407. To prepare this lime-water, keep a barrel of water in the bottom of which is 2 in. quick-lime. Stir this up well and allow it to settle in time for each batch, and keep it well supplied with quick-lime so that it may be active.

408. Bread from Arizona-grown wheat is frequently complained of as poor. Possibly this device may correct it, as it did large quantities of flour in the early days of the war.

409. For an army operating on a line of railroad, a bakery at the general or secondary base can supply it. In camps of any permanence, iron portable ovens will establish temporary bakeries. For marching columns bakery wagons in which men can knead the dough, and travelling ovens to go where guns can pass, are practicable.

410. For brigades or less, not in permanent camps, the baking, as the cooking, must as a rule be done by company.

411. The more common methods are: Barrel ovens, Dutch ovens, mess pans, frying-pans, holes in the ground.

412. The barrel oven: A barrel with its head out is laid on its side in a hollow, it is covered throughout with wet clay 6–8 in. and this with dry earth for 6 in., leaving a 3-in. opening at the top of the further end for a flue. The staves are burned out, and for use when heated the front and flue are closed.

413. A Dutch oven is a heavy flat iron pot with short legs and top fitting with a flange. It is heated by coals beneath and above. It is economical to use a trench with several. This is well adapted for com-

pany cooking when fuel and transportation are abundant.

414. The Buzzacott field-oven, recently invented and tested, appears well adapted for baking and company cooking. Its capacity is greater and its weight and cost are less than the Dutch oven, and it can be carried wherever there is moderate transportation.

415. To bake in mess-pans. Cut off 1½ in. of the iron rim, leaving a rough edge; fill a perfect pan two-thirds with dough and cover with a cut pan inverted; place these in a hole 18–20 in. deep in which a fire has burned 5–6 hours and from which all the cinders but a bed 2–3 in. deep have been removed. Cover the pans with hot cinders and with earth and leave them 5–6 hours. The rough edges of the upper pan permit the escape of gases and the bread will not rise to the top.

416. To use a frying-pan. Grease it and set it over embers till the grease melts; put in dough rolled ½ in. thick and set on the fire; shake the pan to prevent sticking; when the lower crust forms, remove the bread and set it up on edge close to the fire and turn it occasionally. One man with six pans will bake 25 lbs. bread in less than an hour.

417. To bake bread in a hole. The simplest baking is to fill a small hole in the ground with a wood fire; when thoroughly burned, to place on a stone a mixture of flour, salt and water, cover with a tin plate and surround with hot ashes. Regulate the heat, for above 212° will toughen.

418. Bread sour from an excess of acid if cut into thin slices and toasted will be edible by volatilization of acid.

Stale loaves soaked in water and heated 250–300° in an oven become fresh, but must be eaten within 24 hours.

Stale bread cut into thick slices and toasted is thereby freshened.

419. For transportation loaves should be laid on their sides or ends, not on their bottoms.

An army wagon will carry 1,400 18-oz. rations of bread, and with side-boards 1,800.

Hard Bread.

420. Hard bread is unfermented dough thoroughly baked, not burned. Bulk for bulk it is more nutritious than soft bread on account of the water being driven off, but men do not thrive on it as a continuous diet.

421. Hard bread crumbles out of the original packages or when they are broken, and the bulk of the ration (16 oz.) is not sufficient to satisfy the stomach, so that the allowance is apt to be eaten in advance on the march.

Corn Meal and Oatmeal.

422. Corn meal may be substituted for flour, 20 for 18 oz. It contains as much N and four times as much fat, 6–7 per cent., and is very nutritious. It should be freshly ground from selected corn, kiln dried and well bolted.

It does not keep well and, especially if not thoroughly cooked, cannot be forced on persons unaccustomed to its use.

423. Oatmeal carefully cooked is very nutritious, developing ounce for ounce 130 foot-tons of potential energy against 87.5 for bread.

It keeps well, is easily cooked, and while it lacks adhesiveness for making large loaves, small flat cakes can be preserved. This is good military food.

424. Oatmeal as a hot or cold gruel is extensively and profitably used by laborers on hard work, and is recommended as an extra issue for men on guard at night or on heavy fatigue.

Cheese.

425. Cheese is nutritious and economical, being rich in N and in fat. A half pound contains as much N as one pound of meat and a third of a pound contains as much fat. The opinion that it is very indigestible is not well founded.

426. The richer cheeses decompose easily and all are liable to do so in hot climates; hence it is not well kept in store.

427. Cheese was formerly but is no longer issued to travelling troops, 25 lbs. to 100 rations. It is recommended as an occasional addition to the mess table.

428. An obscure fermentative change sometimes develops an active gastro-intestinal poison (tyrotoxicon) in cheese that appears sound.

Dried Vegetables.

429. Beans or pease (dried) at 15 lbs. to the 100 rations are part of the regular issue.

Beans contains several times as much N as bread, and supplement it admirably. But they are indigestible unless well cooked, and should be soaked in soft water about 12 hours and be boiled until they are tender, which will require two or three hours more.

430. Pease are chiefly used for soup, which is the only state in which men like them as a rule.

Their richness in N makes both valuable substitutes for meat.

No amount of boiling will soften old beans. Such should be soaked 24 hours and then be crushed and stewed.

Hard water is unsuitable for use with either beans or pease, as the lime salts make the legumen insoluble.

431. When lime water must be used for cooking beans, a certain amount of the hardness can be removed by boiling, when part of the lime is precipitated and the supernatant water if carefully poured off can be used.

Fresh and Canned Vegetables.

432. Fresh vegetables are always desirable for variety, for their own sake as food, to give zest to the appetite, and probably as an aid to digestion and to the assimilation of other food.

They have special value as antiscorbutics.

433. Mushrooms are an agreeable addition to the company table, and when grown naturally and eaten fresh are nutritious. The spawn is easily obtained and they are readily cultivated.

A mushroom should peel easily, be a clear pink, and have a curtain attached to the stalk.

434. The tomato is a better antiscorbutic than the potato. Its acid is malic, which it holds free at a little over $\frac{3}{10}$ of 1 per cent. and about as much in combination with bases.

435. The tomato is excessively watery, some specimens as canned containing 97.6 per cent. fluid, but probably this could be reduced.

Canned tomatoes with part of the water driven off might properly be supplied, if not as an outright issue at least at a very low price, to companies.

Canned Foods.

436. Canned foods sometimes ferment, and the presence of gas which requires rejection is shown by the end bulging.

It was formerly supposed that two sealing holes in the end of the can indicated that the gas of fermentation had been allowed to escape through a new vent, which afterward was sealed. But two holes are not a certain sign of bad goods, because some companies habitually make use of two in their original packing.

437. First-class canned goods have on the label both the name of the factory and that of the wholesale house through which they are sold. Doubtful goods have a fictitious factory name and no dealer's name. These are easily avoided in peace, but under the pressure of war supplies deteriorate and must be critically watched.

Cheap Food.

438. Occasionally men are fed through the company fund with a cheaper grade of food, but as a rule (although not universally) such is apt to be defective. This is especially true of molasses, as bought outside. Speaking generally, it is not economy to buy food costing much less than that of the same name supplied by the Subsistence Department.

Concentrated Food.

439. Life and vigor can be sustained with some loss of weight for a few days on less than the standard

allowance of food, when that is put in a concentrated form.

The minimum amount is 11 oz. a day, and the maximum time is one week.

440. These foods develop force but do not supply tissue loss, and troops operating under their spur must have sleep and the carbo-hydrates afterward.

The German pea sausage as a constant diet is probably over-rated. It consists of pea flour, fat pork and a little salt, and is issued cooked. It readily makes soup.

441. Mixing together, cooking and baking 1 lb. each of flour and meat, $\frac{1}{4}$ lb. suet, $\frac{1}{2}$ lb. potatoes, with a little sugar, onions, salt, pepper and spices—makes a meat biscuit that contains about 10 per cent. water, and keeps unchanged four months. (Parkes.)

442. The extract of beef might make an emergency ration for special occasions, as for pickets and forced marches.

It would be particularly useful after battle, and if each man could be induced to preserve a package on his person it would be of great service to the wounded.

It is a heart stimulant and removes the sense of fatigue, instead of acting as a true food.

Horse Flesh.

443. Horse flesh contains more N and less C and H than beef. It is palatable and stimulating, and horses killed in action or not required in a siege should be utilized in emergency.

Coffee and Tea.

444. Coffee is a gentle nervous stimulant, and as made in garrison insures the water being *boiled.* (See

Water.) It is useful in winter by the warmth it supplies, and in summer it replaces perspiration.

Chiccory and coffee "extracts" are harmless adulterations in garrison.

445. In the field only coffee itself, which probably retards tissue change and certainly stimulates the nervous system without reaction, should be relied on.

The disadvantage of its use in campaign, when it must be issued ground and roasted, is its liability to accidental loss and to damage.

446. Tea has practically the same physiological effect as coffee. The advantage of tea is its lightness and small bulk. Its weight is but one-sixth that of coffee. A water-proof covering is necessary for its carriage, and the most convenient method is in a small glass vial.

447. The men generally dislike tea because of its bitterness when drawn too long, and from the action of iron on it. The vessels for making tea should be scrupulously clean, with no exposed iron.

448. Tea is best made by pouring boiling water on the leaves and letting it "draw," not boil, in a covered vessel.

Besides having the sanitary advantage of boiled water, tea destroys many offensive qualities of water containing suspended and dissolved organic matters.

If hard water must be used, it should first be well boiled with a little carbonate of soda.

Scurvy and Antiscorbutics.

449. Scurvy is influenced by mental depression and is due to the absence of the salts of vegetable acids in the food.

It is checked by cheerful surroundings, and is removed by the use of fresh vegetables or their salts.

450. The better antiscorbutics are lemon and lime juice; raw potato; tomato; onions; cabbage (fresh cabbage is better than sauer-kraut); vinegar; yellow mustard; lamb's quarter; cactus stripped by fire (the tall varieties contain valuable juice).

451. The best antiscorbutic is the *agave.* To prepare it cut off the leaves close to the root, cook them well in hot ashes, express the juice and drink, raw or sweetened, 1–4 wineglassfuls three times a day. The white interior of the leaves may be eaten.

452. Raw potato sliced and covered in alternate layers with molasses is a good antiscorbutic that keeps well.

Food and Climate.

453. In tropical countries carbo-hydrates form the staple; in temperate, a mixed dietary is used; in arctic, fuel foods, the hydrocarbons or fats.

454. The ration should not be identical over the whole of so large a country as this, nor should it be the same in case of invasion north or south, but should be arranged to suit the climate and the duty, even if at some increase of cost.

Alcohol.

455. Alcohol, formerly part of the ration as whiskey, often suggested for use under exposure, is not desirable in health.

456. In that it is partly oxidized in the blood and transformed into acetic acid, alkaline acetates and then carbonates, and in the sense of retarding tissue change, it may be regarded as a food. (Yeo.)

457. But a part is always eliminated unchanged

through the kidneys and lungs, and in excess of very small amounts it is invariably hurtful.

458. One ounce of brandy or whiskey freely diluted is the extreme quantity to be taken at one time without the risk of depression, and twice that quantity in twenty-four hours is the maximum for a healthy man.

459. Its primary stimulating effect on the nervous and circulatory systems is temporary, and is followed by a sedative, and finally a depressing effect on the nerves.

460. The subjective feeling of warmth is due to the dilation of the vessels of the stomach and skin.

461. In small quantities it exercises no influence on the temperature of a healthy adult, medium quantities lower the temperature a little, and large quantities produce a fall of several degrees for several hours. (Binz.)

462. Its effect on the bodily temperature is one cause of the danger of its use in severe climates; and the experience of large bodies of troops under all conditions of heat, cold, and exposure has demonstrated their greater health and efficiency when no spirits have been used.

463. Therefore in garrison, or with working parties, or on forced marches, to say nothing of battle, small quantities have no influence, and the moment it is felt it is hurtful.

464. Its use as a medicine in disease is entirely different from that as a beverage in health, and is a question of therapeutics, not of hygiene.

465. Taken habitually, alcohol leads slowly to morbid changes in all parts of the body which become permanent, and its daily "moderate" use is more

dangerous physically to the consumer than are periodical debauches.

466. Even in moderate quantities alcohol disturbs muscular action, alters the disposition, and deranges the judgment; but the effects of similar quantities upon different persons often are very unlike.

467. Independently of the disease it may induce, the untrustworthiness of the intemperate, the serious consequences of their action and their inaction, are sufficient reasons for discouraging the use of alcohol in military life. And although no man expects to be a drunkard, nor becomes one at a single step, the entire avoidance of spirits is always safer, and to many is easier than a moderate use.

468. Beer contains about 3 per cent., and brandy and whiskey about 42 per cent. alcohol.

The inveterate beer-drinker is always a nuisance, although not so active a one as the whiskey-drinker.

469. Binz, of Bonn, probably the best scientific authority on the subject, thus sums up his views: "The habit of taking alcoholic stimulants apart from meals is a public evil, from a sanitary, economic, and intellectual point of view."

470. What is thus true of civil life is doubly so of the military service, where clear and swift judgment is required of the leaders, and prompt co-ordinate action of the subordinates.

Tables of Food Values.

471. These tables of food values by Prof. W. O. Atwater, the latest determinations on the subject, and the explanatory remarks, are extracted from Billings's National Medical Dictionary (1890).

472. The potential energy of food represents its

ability to furnish heat and muscular or other forms of energy.

473. Potential energy is estimated in calories.

474. A calorie is the heat required to raise one kilogram of water 1°C. (or one pound of water about 4° F.).

475. A foot-ton is the energy (power) to lift one ton one foot, and one calorie corresponds to 1.53 foot-tons.

476. A gram of albuminates or of carbohydrates is supposed to yield 4.1, and one of fats 9.3 calories; hence weight for weight when digested the fats have a little more than double the full value of the others.

477. PERCENTAGE OF DIGESTIBILITY OF NUTRIENTS.

Food Materials.	Albuminates.	Fats.	Carbo-hydrates.
Meats and Fish..........	practically all	79–92	......
Eggs....................	" "	96	......
Milk....................	88–100	93–98	?
Butter..................	......	98	......
Oleomargarine...........	......	96	......
Wheat bread.............	81–100	?	99
Corn meal...............	89	?	97
Rice....................	84	?	99
Peas....................	86	?	96
Potatoes................	74	?	92
Beets...................	72	?	82

Atwater, Nat. Med. Dict.

478. STANDARDS FOR DAILY ALLOWANCE OF FOOD.

	Albuminates.	Fats.	Carbo-hydrates.	Total.	Potential energy.
	Grams.	*Grams.*	*Grams.*	*Grams*	*Calories.*
Child to 1½ years....	20–36	30–45	60–90	140	765
" " 2–6 years...	36–70	35–48	100–250	295	1420
" " 6–15 years..	70–80	37–50	250–400	443	2040
Aged man..........	100	68	350	518	2475
Man at hard work, German..........	145	100	450	695	3370
Active laborer, English..............	156	71	568	795	3630
Hard-worked laborer, English....	185	71	568	824	3750
Man at moderate work, American..	125	125	450	700	3520
Man at hard work, American........	150	150	500	800	4060

1 lb. avoir. = 453.6 grams. 1 oz. = 28.3 grams.

Atwater, Nat. Med. Dict.

479. NUTRIENTS AND POTENTIAL ENERGY IN ACTUAL DIETARIES.

	Albuminates.	Fats.	Carbohydrates.	Total.	Potential energy of nutrients.
	Grams.	*Grams.*	*Grams.*	*Grams.*	*Calories.*
Carpenter, Munich..	131	68	494	693	3194
Blacksmith, England............	176	71	667	914	4117
German peace ration	114	39	480	633	2798
German war ration..	134	58	489	681	3093
German extraordinary ration, Franco-German war ...	157	285	331	713	4652
Factory operatives, mechanics, etc., Mass............	127	186	531	844	4428
College foot-ball team, food eaten..	181	292	557	1030	5742
Machinist, Boston...	182	254	617	1053	5638
Teamsters and other hard workers, Boston.............	254	363	826	1443	7804
Brick-makers, Mass.	180	365	1150	1695	8848
U. S Army ration..	120	161	454	735	3851
U. S. Navy ration ..	143	184	520	847	4998

This table represents what is eaten, rather than what is absolutely necessary.

Atwater, Nat. Med. Dict.

IV.

HABITATIONS.

Soil and Soil-air.

480. Soil, hygienically, is that portion of the earth's crust that may affect the health.

It consists of mineral, vegetable, and sometimes animal substances; and air and usually water are contained in its interstices.

481. The air in soil is generally rich in carbon dioxide (CO_2), and may be charged with effluvia from organic decomposition. As much as 26.3 to 54.5 volumes CO_2 per 1,000 air have been found 13 feet below the surface.

482. The subsoil air is always in motion, laterally and vertically.

483. The movement of subsoil air is due to changes of temperature in the soil and to the effect of rain, which at first displaces the superficial and later the deeper air by changes in the ground-water.

The direction of its movement depends upon the least resistance.

484. The artificial warmth of a house draws the soil-air (ground-air) to its site and into it, especially when the surface is frozen or closely paved, unless the cellar is air-tight.

485. Hence, air from cess-pools, broken drains and buried decomposing matter of all kinds will pass into the cellar as in a flue.

486. Dug-outs should only be tolerated in whole-

some soil, and all permanent habitations should be cemented below the level of the ground or be built on arches.

Soil-moisture and Ground-water.

487. Besides air, soils contain water, divided into moisture and ground-water.

488. The soil is moist when it contains air as well as water.

489. Ground-water fills the interstices, so that except as its particles are separated by solid portions of soil there is a continuous sheet of water.

490. Soil-moisture is derived from the rainfall, and its amount depends upon the supply and upon the power of the soil to absorb and retain it.

491. In relation to moisture, soils are divided into permeable and impermeable; the former being unweathered granite, trap and metamorphic rocks, dense clay, clay slate, hard limestone, etc.

However, the driest granite and marble will contain about a pint of water in each cubic yard.

492. The permeable soils are the chalks, sands, sandstones and vegetable soils.

493. Average sandstone absorbs about 25 per cent., and ordinary vegetable mould from 60 to 75 per cent. of rainfall.

494. Much surface moisture is derived also from the rising and falling ground-water, by evaporation from it and by capillary action.

The air of habitations and their walls are thus directly affected.

495. Ground-water or subsoil-water, the water-level of the engineers, is a subterranean sheet lying at different depths (from two or three to hundreds of

feet) below the surface, not necessarily horizontal, in constant motion, generally towards the nearest water-course, with changing level and varying flow, and affected by such obstacles as the roots of trees, deep wells and low drains.

496. Soil-moisture, the superficial dampness immediately under the surface, affects health by aiding decomposition of contained substances, by predisposing to catarrhal, rheumatic and neuralgic affections, and by furthering consumption.

497. Ground-water by its influence upon soil-moisture may affect the health of animals as well as of men.

In two stables identical except the distance of the ground-water (in one 2½ ft., in the other 5–6 ft.) from the surface, horses were constantly sick in the one and not in the other, and equal health was attained by draining the damper soil.

498. Soil is dried: (1) By deep drainage, (2) by opening the outflow or diverting the inflow.

499. Very deep drainage is not always essential. Lowering the ground-water as little as two feet has been known to make unhealthy sites salubrious.

500. But newly-established posts, on all but the most impermeable soils, should be underdrained 8–12 ft. deep with lines 10–20 ft. apart.

In the extreme south deep underdraining should be carried out, even in apparently sandy soils.

501. Tiles once properly laid are practically indestructible. In laying drains the bed should be hollowed in undisturbed soil and the workmen should never stand less than one foot from the bottom.

502. A fall of 1 ft. in 100 is sufficient, and with good workmanship 6 in. is enough.

503. With a grade less than one in a hundred, or with a bad foundation, begin at the upper end. With a greater grade begin at the outlet.

Character of Soils.

504. Granite, metamorphic and trap rocks are usually dry and healthy sites.

When weathered, granite is said to collect vegetable decay and to absorb moisture.

505. Clay slates are impermeable and healthy, but drinking water is scarce.

506. Limestone is generally dry and healthy, but apt to be cavernous with communicating rifts through which contaminations may pass to the drinking water.

Magnesian limestone is undesirable as a site.

507. In limestone regions the water is hard, clear and sparkling.

508. In limestone ranges marshes at great elevations are not uncommon.

509. Permeable sandstones, the air and soil being dry, are very healthy; but shallow sandstone underlaid by clay may be damp.

510. Deep gravels are always healthy, unless lower than the general surface.

Gravel hillocks are the very best sites.

511. Pure sand, deep and free from organic matter, is healthy.

But sands lived upon soon become charged with refuse, which passes through them laterally for long distances.

Some sands have vegetable debris intermixed, and others have water within a few feet of the surface held by underlying clay.

512. Clay and alluvial soils generally are suspicious. Water is retained in and air is damp over clay.

Vegetable matter and impermeable strata are liable to be intermixed in alluvials.

513. Well cultivated soils are generally healthful, rice fields being the exception.

Rice plantations should not be tolerated near military posts.

514. Made soils, especially near towns, are frequently impure and should always be avoided for camps or cantonments.

Sites, Independently of Soil.

515. Unhealthy situations independently of soils are: Enclosed valleys, ravines or the mouths of long ravines, ill-drained ground, the neighborhood of marshes, especially if the wind blows from them, and the northern slope of mountains.

516. On sanitary grounds an enclosed valley is objectionable as interfering with free ventilation on a large scale and as tending to concentrate and retain drainage.

517. There is apt to be a current of air in one direction or the other during the day, and in reverse at night, through ravines. The out-current where vegetation is profuse and decaying is impure, and posts should not be established near their mouths.

518. No site, whatever its altitude, unless thoroughly well drained, is acceptable if dominated by surrounding heights.

519. Proximity to marshes, especially on their level, is undesirable, and to be in the course of prevailing winds in southern latitudes is apt to be disastrous.

520. In the warmer latitudes, if military posts are

required near streams they should be on the southern bank.

521. The best situation for a post is a divide or saddle-back, unless it is too much exposed or without water.

Nearly as good a site is near the top of a slope, and if the crest protects against fierce winds it is better.

When there is a choice, the southern is better than the northern side of mountains or high hills.

Vegetation near Sites.

522. As affecting sites, vegetation is classed as herbage, brushwood and trees.

523. Herbage, or closely-lying grass, is always healthy. Bermuda grass is well adapted to hold shifting southern sands. (Lupine, a shrub about two feet high, has a similar use.)

524. Herbage should always be kept closely trimmed and weeds are not to be tolerated.

525. All rank vegetation about a permanent post should be cut while in full growth and be promptly burned before decay.

526. But it is better not to move such, if it is primitive, about a temporary camp, lest the disturbance of the soil induce malaria.

527. When vegetation is removed, it should be in the heat of the day. (This applies to everything between grass and trees.)

528. Heavy brush about a marsh probably impedes malaria and should not be removed.

529. Vegetation that obstructs the sun's rays renders evaporation from the ground more difficult, and the roots of trees impede the passage of water through the soil.

530. Forests therefore keep the ground cold and moist in cold countries. Their removal makes the extremes of temperature more marked, with an average rise.

531. In hot countries the shade of vegetation cools the ground. Evaporation from the surface is lessened, but that from the vegetation itself perceptibly lowers the temperature.

532. Trees and tall shrubs check the velocity of the air, and belts of such vegetation serve as a barrier against malaria.

533. But where the air becomes stagnant by such intercepting growths in thick clusters, decaying vegetation may produce fatal disease.

534. In frostless climates the eucalyptus absorbs and evaporates eleven times the rainfall, and thus drains wet ground and exhausts the poison of malarious localities.

535. The common sunflower of the east has similar properties.

536. Trees should be removed only with judgment. In cold countries they break cold winds, in hot countries they cool the ground and they may protect against malarial currents.

Where they cut off sunlight and air from a domicile and make it dark and damp, they are doing harm.

537. Some officers dread camping in the woods, and always select an open field. That is the result of imperfect knowledge. The character of the forest must be considered. The Romans habitually encamped under trees, and their example is generally good.

538. In establishing a permanent post remove no more trees than absolutely necessary, until time shows which can be spared.

539. Summary as to permanent sites: Avoid soil moisture, ground-air from decomposing organic matter, prevailing winds charged with malaria, excessive elevation and unnecessary exposure to extremes of temperature.

Drain deeply, except through impermeable underlying rock; carry off storm water; clear away brush, except about marshes; if possible, cultivate grass and keep it short over adjacent ground; preserve trees, to remove with judgment later; pave under houses, and in warm climates raise on piers; and preserve the soil from pollution by removing impurities.

Barracks and Quarters.

540. Barracks, particularly if standing below higher ground, should be protected from water by trenches deeper than the foundation wall, filled with loose stone to form blind drains, from which the collected water must be led to some lower point for escape.

541. Foundation walls should be laid in mortar of cement and sand and be smooth on both faces. If not drained on the exterior, the outer space to be filled with gravel, which will conduct rain-water flowing down without the wall into the soil, if porous. But if the soil be clayey or springy, the bottom of the wall must be drained, and it is better to have drains under the walls in all cases.

542. Cellar walls that are laid dry, or slightly pointed on the inside, have their stone-work dislocated by freezing, with the risk of water entering.

Where sandstone, soft limestone, or brick is used, the outside of the wall should also be coated with melted coal-tar, and a damp-proof course be carefully

introduced to check moisture rising by capillary attraction.

543. House walls should be furred as well as plastered. Otherwise the house will be damp and cold.

544. Besides healthful sites, the essential conditions of barracks are dryness, warmth, light, floor-space and air-supply.

545. There is no good reason for preserving the traditional hollow square in the arrangement of the individual buildings at a post, and while they must be arranged with due regard to military convenience for assembly and drill, they should be placed with relation to sunlight and the prevailing winds so as to get the utmost advantage of locality and climate.

546. Officers' quarters should face nearly south, or should have as much of such an exposure as possible; and when two are under one roof they should not stand east and west, if it can be avoided.

547. A southern exposure is warmer in winter, and on account of the prevailing winds, at least at our interior posts, is generally cooler in summer.

548. Parkes advises the long axis of barracks to be north and south, that the sun may fall on both sides of the building.

But for our simple buildings, facing south, the sunlight sufficiently floods the rooms and they are swept by the southerly winds.

Floor-space and Ventilation.

549. In the squad-room every man should have 600 cubic feet air-space and 50 square feet floor-space, and south of 36° N. these should be 800 and 70. (The official recommendations for English troops in India

range from 1,500 to 3,000 cubic feet, and from 75 to 150 square feet.)

550. Squad-room should not be less than 12 nor more than 14 feet high, nor more than 24 feet wide.

Excessive width is a common error.

551. When it is necessary to quarter troops in ordinary dwellings, the rule is:

For rooms 15 feet wide, one man to every yard in length;

" " 15–25 feet wide, two men to every yard in length;

" " more than 25 feet wide, three men to every yard in length.

552. Ventilation is important, because after the air has been destroyed by respiration it is immaterial whether the original supply was 600 or 6,000 feet.

553. Air is a mixture of 21 parts of oxygen (O) and 79 of nitrogen (N), practically 1 : 4, and it also carries watery vapor from $\frac{1}{200}$ to $\frac{1}{60}$ of its bulk and contains normally 4 parts of carbon dioxide (CO_2) in 10,000.

554. The air that enters the lungs meets in their very delicate membrane blood returning from all parts of the body, into which blood it discharges O and from which it receives CO_2, watery vapor, and organic matters, all forms of body waste.

555. Now CO_2 by itself is not particularly harmful, and where that gas alone is added, the air may be breathed with impunity when it contains many times the normal amount, as at certain baths where it reaches 150 parts in 10,000.

556. In a dormitory CO_2 is dreaded because it represents a certain amount of respired oxygen, so much taken from the room; and just as this CO_2 is inhaled,

by so much does it interfere with the release of fresh CO_2 from the blood.

557. But the effects of breathing expired air are much more injurious than would be the inhaling of an equal amount of CO_2. This is due to minute quantities of decomposing organic matter being taken into the lungs anew.

558. The exact amount of organic matter so given off has never been determined, but it is nitrogenous, is highly oxidizable, is very fœtid and is probably intimately connected with the expired watery vapor.

559. That CO_2 is not the destructive agent has been shown by confining a mouse in a jar in which sponges with baryta water removed CO_2 as it developed. The exhaled aqueous vapor was absorbed by calcium chloride. *Fresh air was pumped in as required*, but the mouse died at the end of 45 minutes. Potassium permanganate demonstrated the organic matter.

560. The mouse died, not from the presence of Co_2, for that was removed; not from the want of O, for that was supplied; but by the direct poison of the expired organic matter from the lungs and probably from the skin.

561. A man who loses his life by plunging into a reservoir of CO_2, as a deep well or cistern, is simply drowned as he would be were fresh air excluded from his lungs by water.

It is, however, possible that in such cases other actively poisonous gases may sometimes be present.

562. Conspicuous illustrations of poisoning by foul air, not CO_2, are the Str. Londonderry, where 72 out of 200 died while confined in a small cabin; the Black Hole of Calcutta, where 146 were confined overnight in a space of 18 feet square, with two small windows,

and only 23 were alive the next morning, most of whom died afterward of typhus fever; after Austerlitz, of 300 Austrian prisoners, confined in a very small place, 260 died "in a short time."

563. Horses transported in unventilated cars have been killed under precisely similar conditions.

564. Brown-Sequard, condensing watery vapor from human lungs, produced a liquid that injected under the skin of a rabbit was speedily mortal. There is a volatile toxic principle in expired air.

565. The fever of the slave-ships, the camp fever and jail fever of former times but always ready to reappear, the immigrant fever of the Irish packets of past years, and the typhus of to-day are all a similar outcome of the poisoning of man by man.

566. We do not now often meet these immediately serious results of want of ventilation, but what is generally found is deficiency of nutrition leading first to anæmia or deficient blood, then to loss of vigor, and then to general diminution of resistance to disease.

567. Should there be no accidental source of pure CO_2, and ordinarily there is not in barracks, all that is in excess of 4 to 10,000 is the CO_2 of respiration, or, as it is sometimes called, "carbonic impurity."

568. Carbonic impurity, then, in itself is not dangerous, but it is indicative of danger.

569. Natural air contains 4 parts CO_2 to 10,000, and up to 6 or 7 parts hygienists speak of it as "allowable impurity." Beyond that it is a sign that there is too great contamination by the accompanying impurities.

This condition is what physicians know as "crowd-poisoning."

570. The most practical test for this depressing aerial poison is the sense of smell. A "close" or

"musty," to say nothing of an offensive smell means harm.

571. Crowd-poisoning may also occur in the open air, as when large bodies of infantry march in close order in warm weather in a stagnant atmosphere.

572. Civilized men in their ordinary habitations may suffer from: (1) The hurtful emanations from healthful human bodies; (2) gases, more or less poisonous, the products of combustion; (3) the compounds, sometimes odorless and sometimes giving smell, collectively known as sewer-air; and (4) those particulate emanations, invisible and unrecognized except by their results, that cause the contagious diseases.

573. In barracks, the first, the nitrogenous out-put of the body, is the ever-present condition; sewer-gases, or other direct poisons, except carbon monoxide (CO), are rare; and contagious diseases, except accidentally in the very first stage, are seldom found.

574. But in hospitals the emanations from diseased bodies are constantly present and require to be neutralized or removed.

575. A man living by himself out-of-doors would have so much fresh air as not to suffer from the conditions just noted; and it is the object of improved civilization to reduce these conditions within doors to the minimum.

576. Ventilation is securing a change of air, and the more complete with the least discomfort the better.

577. "Perfect ventilation can be said to have been secured in an inhabited room only when any and every person in the room takes into his lungs at each respiration air of the same composition as that surrounding the building, and no part of which has re-

cently been in his own lungs or those of his neighbors, or which consists of products of combustion generated in the building, while at the same time he feels no currents or draughts of air, and is perfectly comfortable as regards temperature, being neither too hot nor too cold." (Billings.)

578. Perfect ventilation requires a room of special construction, and thirty times as much fuel as to heat a room of the same size in the ordinary way.

579. Good ventilation means keeping the vitiated air diluted to the standard of allowable carbonic impurity. (6–7 in 10,000.)

580. All ventilation depends upon (1), the diffusion of gases, and (2), the entrance and exit of air from and into the outer atmosphere.

581. The diffusion of gases is the property by which every gas will freely and rapidly expand into the space occupied by another gas, much as though that space were a vacuum, and the mixture will not separate.

582. The carbon dioxide does not sink to the bottom of the room, although probably in an undisturbed atmosphere organic particles thus gravitate.

583. A man in repose breathes 18 times a minute, about two-thirds of a pint at a time.

He exhales 12–16 feet CO_2 in 24 hours, or .6 cubic foot per hour.

He also discharges from his lungs and skin 25–40 oz. water, requiring 211 cubic feet per hour to maintain as vapor.

And he disengages from his lungs and skin about 300 grains per day decomposable organic matter, of which from 30 to 40 grains is given off from the lungs.

584. The amount of this nitrogenous organic matter

is determined with great difficulty; but one fair test is the sense of smell, and a better one, although difficult, the amount of CO_2, which is a measure of comparison.

585. Combustion may add to the impurities, one pound of anthracite coal consuming 32 cubic feet O; one foot coal gas gives out 2 feet CO_2.

586. Air once breathed loses 5 per cent. O and gains a little more than 5 per cent. CO_2.

587. To keep the CO_2 down to the standard of allowable impurity requires 3,000 cubic feet fresh air per man per hour.

588. This relatively large amount is needed because a man does not breathe out of and into separate reservoirs, but contaminates the air about him which he and his neighbors must continue to use.

589. The rate of supply depends upon the size of the apartment, the occupancy being the same.

A space of 100 cubic feet must be renewed 30 times an hour, while one of 1,000 feet would only require renewal thrice.

590. These poisonous matters do not immediately fly off uniformly into space; and diffusion, although a steady and reasonably rapid process, does not directly overcome the effects of currents caused by varying temperature.

591. When much difference in composition exists between the upper and lower strata, the upper is usually the most impure.

592. For a room permanently occupied, with ordinary ventilation, a capacity of 1,000 cubic feet per head is the lowest limit, but for healthy soldiers in ordinary squad-rooms in temperate climates 600 feet per man is sufficient, under proper provisions for renewal.

593. Cavalry should have somewhat greater allowance than infantry, to dissipate unavoidable stable odors.

594. Emanations from the sick in hospitals, having specific poisons of their own, require extreme dilution.

595. It is probable that the greater the amount of fresh air, especially if it contains ozone, the more rapid is the oxidation and simultaneous destruction of such disease-causes.

596. Ozone is an allotropic condition of oxygen, probably arranged as O_2O.

597. Floor space should be 60–70 feet per man, but the area will vary with the capacity.

598. Thus, practically a room 10 feet high requires 60 square feet, and one 12 feet high 50 square feet per man.

599. For ventilation, all height above 12 feet may be disregarded.

600. The supply of 3,000 feet per hour requires the 600 feet per man to be renewed 5 times within that period, and this, if the apartment is small, is sometimes difficult and at ordinary temperatures uncomfortable.

601. Thus, through a space of 500 cubic feet supplied by an inlet of 12 square inches the movement would be at the rate of 10 feet per second, or nearly 7 miles an hour; through 24 square inches it would be 5 feet or 3.4 miles.

Therefore in a small room uncomfortable draughts would be created.

602. Ventilation of larger spaces will be easier because the currents are more readily broken in them, but much depends on the locality and the size of the inlets.

603. All natural ventilation, independently of the diffusion of gases, depends practically upon differences of temperature whereby the relative positions of parts of the atmosphere are changed.

604. External ventilation depends on heat, a conspicuous illustration being the trade winds.

605. Where temperature is uniform over large regions, especially if it is very hot, the air may not move much and the oppressive feeling of stagnation is not imaginary.

606. Probably a considerable source of the exhilaration of a sea voyage depends upon the boundless supply of absolutely pure air.

607. But within enclosed walls provision must be made for the escape as well as the entrance of air.

608. The simplest method is through open doors and windows on opposite sides of a room, so that the wind may blow through. This is perflation.

609. This should be practised daily in every barrack, to sweep out all the air formerly present.

The only exception is when rain or snow would beat in on the windward side, but even then the opposite side must be opened part of the day.

610. This cannot be kept up in severe weather while the room is occupied, and in any weather where the external temperature is much lower the discomfort of draughts will forbid the partial opening of windows.

611. Diffusion of gases establishes uniform foulness as well as freshness, but has little effect over floating organic matter.

612. Natural ventilation of buildings depends chiefly on aspiration. The outer air in motion leaves

a possible vacuum over points of exit, into which the inner air moves.

613. But the air will not pass out unless there is opportunity for other air to take its place.

614. We must therefore have a difference of temperature and opportunity for both ingress and egress of air, as illustrated by a common stove.

615. Hence in attempting to warm a house by a furnace, the effort "to keep the heat in" by closing the openings fails, but to open a window for the escape of cold air allows the warm air to replace it.

616. The ordinary sources of contamination of contained air, besides the human body, are: (1) Leaks from sewer-pipes; (2) up-currents from imperfect traps in waste-pipes; (3) decomposition of vegetable matter in closets and cellars; (4) products of combustion.

617. There is no excuse for decomposing vegetation within the building, which is very hurtful, and its prevention is simply a matter of police.

(For defective plumbing, see *Sewerage*.)

618. Leaking gas-pipes are occasionally a serious contamination in quarters.

619. Carbonic oxide, or carbon monoxide (CO), is one of the products of combustion, especially of coal.

This is an active and deadly poison, inodorous, which escapes freely through the joints of stoves and directly through red-hot cast iron.

Some coal gives out sulphur compounds which betray themselves, but CO is inodorous.

620. The fresh-air supply of heating furnaces should be carefully guarded against contamination from drains and slop deposits.

621. Steam and hot-water coils do not pollute the air.

622. The introduction and extraction of air by machinery is necessary in large and complex buildings, but not in ordinary barracks where the change depends upon the movement of the external atmosphere and upon difference in temperature within and without.

623. In winter when doors and windows must be closed, the difference of temperature is a chief factor, and ventilating openings are smaller as this difference increases.

624. Generally the section-area of inlets must equal that of outlets.

Exception: Where a strong out-going current over a large area, like a chimney, makes the indraft through small sections much more rapid.

625. The following are simple methods for the admission of air, requiring no special appliances:

(1). Where the sashes do not fit accurately, wedges between them will allow a considerable current of air to enter the length of the crack and escape by the chimney or other flue.

(2). Raise the lower and lower the upper sash; air will enter where the displaced borders fail to fit closely.

(3). Raise the lower sash a few inches and fill the space beneath with a light board. Air enters where the sashes no longer join.

(4). Where the sashes are double, always have a movable pane in the outer one.

626. But, generally, some special method of direct communication with the outer air is better.

627. For ordinary climates fair ventilation can be established by a box or tube running across the room

under the ceiling, open to the outer air at each end, with a perpendicular diaphragm in the middle. The sides are perforated and the air will enter from the half toward which the air is blowing and will escape through the other half. If necessary, the amount of air can be controlled by valves at the extremities.

628. The English authorities call for 24 square inches per head for both inlet and outlet. That is excessive for this country with its greater range of temperature.

629. All air shafts should be smooth in order to relieve friction, which greatly retards air.

630. Air shafts must be judiciously placed, (1) in order to avoid direct currents between entrances and exits, and (2) because air has a marked tendency to adhere to and roll along plane surfaces instead of immediately diffusing itself through an enclosed space.

631. The most generally convenient method for admitting air to ordinary barracks is to carry shafts from the open air directly under the heating apparatus. Their outer ends should be turned down to prevent wind blowing directly through with violence.

There should be a jacket about the stove, that the air may be warmed before it spreads over the room; or, in the same way it must be conducted upward at the base of steam coils, that it may not spead over the floor while yet cool.

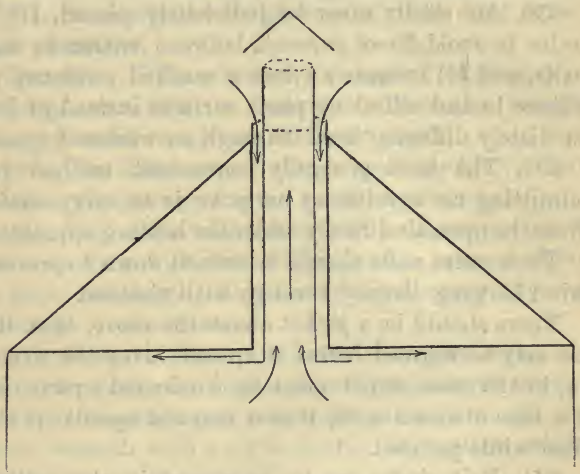
632. Exit shafts are to be placed in the ceiling near the eaves on both sides of the room, tall enough to use the aspirating force of the wind from either direction.

633. In very cold climates, or where there is danger that cold air may enter these channels on one side

of the house while escaping on the other, valves may be arranged to prevent it.

634. A simple plan is that of one or more tubes or shafts through the ceiling, extending higher than the ridge and divided longitudinally into two or four parts. The air enters one and escapes through another channel. This makes no provision for its distribution within the room, and the incoming air is liable to escape at once.

635. A better method is to enclose one tube or shaft within another of slightly larger area and pass both from the ceiling through the ridge, the inner



tube being the longer in both directions and having flanges at its lower end. The heated air will escape by the inner tube and fresh air will enter by the outer channel and be diverted throughout the room by the lateral projections. (See figure.)

636. Ridge ventilation, peculiarly a method for

hospitals but perfectly applicable to barracks, is in substance an opening about 18 inches wide, the length of the ridge, covered by an independent roof 18–24 inches higher, with sides open in whole or in part, and communicating with the ceiling by a boxed opening extending into it.

637. In the cold season, for ridge ventilation must be substituted boxed shafts 18–24 inches square, from the tie-beams to beyond the ridge, utilizing the stove-pipe to assist the outward current.

638. Where there are both inlet and outlet tubes, if the air is warmed before entrance, it should be admitted near the floor; if it is cold, at the ceiling; and the exits should be placed reversely.

639. Small rooms, in which doors are frequently opened, usually require only places of exit.

640. Most walls, unless especially masssve and well built, are permeable to air, and this is particularly true where the plastering is laid directly upon the brick. This permeability of walls is one reason why the apparent want of ventilation is not more serious in its results. But it cannot be depended upon to take the place of a regular system.

641. It is not ventilation when the in-coming air is not fresh or the out-going air does not pass directly into the outer atmosphere.

To connect the air of a sleeping room with that of an attic, whether the latter has windows or not, does not necessarily ventilate either.

642. Fresh air is not necessarily cold air. Air may very properly be warmed without injury before it is breathed.

643. No system of natural ventilation in summer will make the air in the house cooler than that outside.

644. Ventilating shafts should be small and numerous rather than large and few.

645. Ill-ventilated rooms are not immediately fatal; they cause languor, headache, loss of appetite, weakened resistance to disease, and then positive illness. For all this, increased air-space, not medicine, is the remedy.

646. In European armies, consumption, which formerly ravaged them, has almost disappeared with the increase of air-space.

647. In the French cavalry stables prior to 1836 the mortality was 180–197 per 1,000 per annum. In 1862–66 it was 27.5 per 1,000.

In the war of 1859 10,000 horses were kept in open barracks with scarcely any sick and but one case of glanders.

Miscellaneous.

648. It is a mistake to make barracks unduly large, either in the width of the dormitory or by adding unnecessary rooms. The labor of caring for them does not compensate for the possible convenience.

649. Floors should be cleansed with the least possible water, preferably by dry scrubbing, to avoid the ultimate decay of wood and especially the lodging and perpetuation of organic matter in the cracks and fibres.

650. Wainscoted walls become frequent harbors of vermin.

651. On ground floors great care must be taken to prevent slops, dust and debris generally being run under the floors and thus creating a shallow cess-pool there.

652. Plaster, brick and porous stone ultimately

absorb organic poisons, which is a special liability in guard-houses and hospitals.

Such walls should be scraped at least once a year, and be lime-washed twice a year with fresh lime.

653. Steam coils in dormitories should not be placed near the walls, as is the temptation for economy of space, but along the centre of the room.

654. Kitchen waste and dish-water, full of animal and vegetable fragments prone to decomposition, should never be thrown on the ground near by, but be carefully carried away and if possible be disposed of by fire.

V.

CAMPS AND MARCHES.

Camps.

655. Camps are temporary, or are camps of position. The general principles of sites are as true for camps or bivouacs as for permanent posts, and although the former are often determined by immediate and imperative military conditions, nevertheless frequently the two kinds of requirements can be combined by forethought.

656. Secure wood, water and grass if possible, but avoid marshy ground even for a night.

657. If possible, when in the vicinity of the enemy, keep a screen of woods between him and the infantry camp. (Wolseley.)

658. In dry weather when without tents a comfortable shelter is a circle of earth 18 feet in diameter, 3 feet high, the earth taken from the outside, with one entrance to leeward and a small fire in the centre.

659. For personal warmth, a small fire is the best.

660. Where trees are available, a convenient shelter is made by resting a pole on two forks 4 or 5 feet from the ground, against which branches, thick end up, are piled at an angle of 45° on the windward side.

661. Except in the driest regions, men should not be allowed to sleep on the ground without protection from soil dampness.

662. A position on the slope of a hill is warmer

than one on the summit or in the valley. But convenient proximity to water should never be sacrificed to other advantages.

663. Indians and deer rest on hill-tops in summer and in the brush of valleys in winter.

664. Never occupy an old camp-ground, if it can be avoided.

665. The first duties when a halt for the day is made are to designate a place to attend to calls of nature, to post sentinels over the water supply, and to dig latrines with the first tools.

The only exception to digging latrines is when the command is very small, is certain to march the next day, and none will follow.

666. Sinks should be placed so as not to be in the course of the prevailing winds to camp, and must be so that they cannot pollute the water either directly or by soakage.

667. The most useful field-sink is a trench 2 feet wide at the top, from 3 to 10 feet deep, and from 12 to 15 feet long.

Sinks should be multiplied rather than individual ones made too long.

668. The earth should be thrown to the rear and a layer of a few inches from it be covered in every morning, or oftener if necessary.

669. Shallow sinks should be completely covered in one foot from the surface, deep ones three or four feet. All sinks should be covered and marked on breaking camp.

670. Sinks should be screened by bushes. In temporary camps a pole serves as seat; in permanent, box seats open to the rear may be placed.

671. Urinals may be placed nearer the camp, and

in permanent camps it is important to have them of easy access.

672. The kitchen should be promptly established, and in the same relative position as if the camp were to persist a month. A pit should be dug near by for strictly liquid refuse, solid matter to be put in a box or barrel for the police party to transport to a distance.

673. Old camp grounds, liable to be foci of disease, should never be occupied.

Only the most vital exigency allows this general and imperative rule to be disregarded.

674. Whenever a tent is pitched it should be ditched, and as soon as the troops are rested, usually the second day, the company streets and other spaces should be marked out and protected.

675. The general plan of camps is a matter of regulation.

Tents.

676. Four styles of tent are issued:

(1). Conical (modified Sibley) 16 feet, 5 inches in diameter at base; wall, 3 feet; apex, 10 feet; floor, 212 square feet; air-space, 1450 feet; allowance, 20 infantry or 17 cavalry; comfortable for camp or slow march with half that number.

(2). Common ("I" or modified "A"), wall, 2 feet; base, 8 ft. 4 in. × 6 ft. 10 in.; ridge, 6 ft. 10 in. from ground; floor, 57 sq. feet; air-space, 250feet: allowance, 4 mounted or 6 foot men. Each infantry man would have 17 inches to lie in.

(3). Wall, 9 ft. sq. × 3 ft. 9 in.; to ridge, 8 feet 6 inches; floor, 81 feet; air-space, 500 feet; covered by fly, or false roof.

(4). Shelter tent, as described later.

677. Rain swells canvas and renders it impervious to air and especially to organic impurities, making the confined space dangerously foul.

678. Hospital tents are larger wall tents ($14 \times 15 \times 4\frac{1}{2}$ ft. wall, 12 ft. to ridge), that may be opened at each end and thrown together in extension.

679. Tactical considerations permitting, tents should open to the east.

680. A tent is not properly pitched until it is ditched. The tent ditch should be 6 inches wide by 4 inches deep directly at the base of the wall, and thence follow the natural slope of the ground into the company ditch.

681. A careful system of surface drainage should be marked out promptly, for very little camp labor is more profitable.

682. The ground is generally too damp to lie upon directly, and all should sleep upon some dry material, preferably a low platform.

683. Tent walls should be raised for several hours every fair day; all the bedding and the covering of the floor to be withdrawn and exposed to the sun, and every particle of refuse to be removed and, if possible, burned.

684. If floored, every board should be loose and removed frequently, and the ground beneath cleansed.

In warm weather the leeward side may be raised at night.

685. Every tent should have an equal area adjacent vacant, in addition to company street, and be changed to a new site once a week, the old site to be scraped and exposed to the sun.

686. Permanent camps should be as open (or widespread) as possible, for the evils of overcrowding and

the necessity for fresh air, the want of ventilation, and the accumulation of debris always increase directly with the size of the command.

687. In camps of position soldiers are apt to burrow for warmth. As a rule this is hurtful, but occasionally it may be tolerated in very dry soil. The question should be settled in advance after examination.

688. The best shelter where timber is available are the log cabins advocated by Major Smart, Medical Department, to house four men.

Dimensions: Inside, 13×7 ft.; to eaves, 6 feet; to ridge, 10 feet; door in the middle of one long side, chimney opposite, outside of wall. On each side of door-way a double bunk.

This should be roofed with canvas 14×12 feet with a larger fly, both readily detachable for transportation. This hut is large enough, for greater size means more inmates and relative crowding.

689. In the absence of timber, adobe walls, or wattles plastered with clay are available.

690. Minimum space between huts in the same row should equal the height of the walls, and the passage in rear should equal the height of the ridge.

But should this encroach too much upon company streets, which should be ample, camp must be formed in column of divisions.

691. The intervening spaces are always to be carefully policed, for pollution there will ultimately defile the air drawn into huts.

692. The whole camp-ground should be systematically freed from moisture by ditching, otherwise the ground-air will be poisoned.

693. Hut sites and streets are to be well pounded, and dry streets for company formations are important.

694. In fixed camps constant occupation and amusement are indispensable for health and efficiency.

Marches.

695. The direct step of 30 inches at 90 per minute for common and 120 for quick or marching time gives, without halts, $2\frac{1}{2}$ and $3\frac{2}{5}$ miles per hour. In practice it is a little more than 2 and about 3 miles respectively.

696. Double time gives 35 inches at 180 steps per minute. This is not a marching step and is too exhausting for more than rushes and street fighting.

697. Double time is simply a gymnastic exercise which should commence with very short intervals and after prolonged practice should never exceed 20 minutes as a maximum for picked troops.

It yields 175 yards a minute or nearly 6 miles an hour.

698. The German step of 32 inches at 114 in common (3.5 miles per hour) and 120 for attack seems too long a step to be persisted in.

699. The first stage in a long march should always be short, and with troops unseasoned in marching it should be very short, gradually increasing until the maximum is reached in a fortnight.

But troops accustomed to marching drills can attain this maximum sooner.

700. Every 8 or 10 days, besides Sundays, there should be a halt for rest and repairs.

701. The ease with which troops march is inversely to the size of the command. Over good roads 14 miles in 10 hours is good marching for a large army, but a regiment easily makes the same distance in 4 hours.

702. Infantry should not march with mounted troops if it can be avoided.

Infantry should march with as wide a front and in as open order as possible to avoid crowd-poisoning. (See 569, 571.)

703. If possible, move troops in columns parallel to the roads and reserve these for trains, for the great comfort of having the wagons well up when camp is made is full recompense for the somewhat greater fatigue of the route.

704. Frequent halts are desirable: The first of 15 minutes at the end of 2 miles or less, and afterward 10 minutes per hour.

At the first halt men should be encouraged to relieve themselves and to adjust loads.

705. At every halt men should spread out and rest, but should not be allowed to straggle.

To lie down flat, on face or back, is the most restful, always provided they are protected from wet soil.

Men should not be fretted by being held in ranks at a halt whose length is uncertain.

706. The French save time and avoid the mud by squads of 20 or 30 forming a circle, and each man sitting on the knee of the man behind him.

707. No particular command should resume the march until its rear is well closed up and rested.

708. Except with very small commands, leading files should not be allowed to hesitate at minor obstacles of mud and water. Jerky progression is very trying to the muscles and temper of the men at the rear of the column.

709. Music is a real aid in marching; the fife and drum are exhilarant, and a full band stimulates. The tap of the drum assists a common step.

Marching troops should always be encouraged to sing.

710. Raw troops invariably overload themselves at first and throw away recklessly afterward.

The packs should be carefully inspected and everything not authorized be rigorously discarded, but no necessary clothing allowed to be thrown away afterward.

711. New men chafe in the groins and buttocks and suffer from sore feet, and will break down if too hard pressed.

Such men should be sent to sick call when the camp is reached, for relief but not to be readily excused.

For sore feet, see paragraphs 243–5.

712. Carefully bathe the head, feet and genitals daily and keep the hair short.

713. Canteens to be filled with water or weak tea before starting; but as a rule no fluid should be drunk, except with meals or when the end of the march is at hand. The rare exception is when excessive perspiration exhausts.

714. The sensation of thirst is in the fauces and is relieved by carrying in the mouth a small solid like a pebble, which creates moisture by the flow of saliva.

715. Abstinence from fluid while marching is an easily acquired habit of great convenience, while the man who begins to drink water *en route* finds himself in a state of chronic thirst.

716. As a rule do not break camp before daylight, and avoid night marches. The broken rest out-balances any ordinary advantages.

717. Straggling is a serious evil indirectly affecting the health and the morale, and directly concerning

the military vigor of the column. All who claim to be sick should be promptly and rigidly inspected by a medical officer, and those adjudged well be sent forward while the ill are to be carefully transported.

718. An adequate ambulance train should constantly be on hand for the transportation of the really ill, and good troops will always repay thoughtful care by putting forth their best effort in the faith of protection when disabled.

719. A probable illustration of over-marching is the German Garde-Corps, presumably selected troops. They left the Rhine 3d August, with 30,000 infantry; lost less than 9,000 in action, and the morning after Sedan numbered 13,000 for duty; and reached Paris 19th September, with 9,000 present. In about seven weeks, more than 11,000 men were broken down by exertion, for the camps were so short and the operations so active that little sickness occurred.

720. As a rule marching troops are healthy troops.

Carriage of Weights.

721. Nearly every form of knapsack is oppressive, and the blanket-bag is practically the old knapsack; but soldiers must carry certain necessaries.

722. It is not the weight, it is the arrangement that is oppressive. The chest-pressure and that under the armpits and the want of ventilation at the back are harmful.

723. Nevertheless, with care stout troops can be trained up to the use of even the worst forms.

724. The Merriam equipment, with no straps impeding respiration or circulation, with the back free

from contact and the weight chiefly supported on the hips, is the most rational.

725. The next most convenient is the Parker Clothing Case, slung from the shoulder across the body as the blanket roll is worn.

VI.

SEWERS AND WASTE.

Sewers.

726. Sewage is the waste of inhabited places, and sewerage the system of water-carriage that removes it.

727. A sewer is a conduit for the removal of waste, generally meaning excrementitious waste.

728. A drain is a channel to remove water, surface or subsoil; but house-drains sometimes mean those carrying kitchen waste or laundry water into sewers.

729. The separate system is that which carries only sewage.

730. The combined system carries sewage and storm-water together.

731. Sewers carrying storm-water should be oval in section, small end down.

732. Separate sewers should be circular, just large enough to carry house-waste and small enough to be completely flushed.

733. If the sewer outlet is liable to be closed by the tide, special ventilation must be arranged for it.

Sewer-air and Water-closets.

734. Sewer-air, which is a better term than sewer-gas, represents air contaminated with emanations from the solid contents, either in bulk or as coating the pipes.

735. Emanations from fresh and healthy fæcal matter, however unpleasant, do not appear to be mischievous. They are hurtful when bearing specific germs, or after putrefaction.

736. Water-closets and sewers are intended to carry off the products of body waste, and to bar the ingress into habitations of the products of decomposition.

737. The introduction of sewer-air is prevented by: (1) A seal or trap; (2) disconnection; (3) ventilation.

738. If the water-closet bowl is not fouled above the seal, and the seal is of sufficient depth and kept intact, the house is considered safe. But ventilation also should not be omitted.

739. The most objectionable pattern is the "pan" water-closet. It never receives sufficient water in the proper way, and, especially, the pan and container are continually smeared with excrement, gases from which enter the room whenever the pan is drawn back. A pan closet should never be introduced.

740. Next better is the "valve," whose pan receives a greater volume of water and whose receiver is of better shape and smaller.

741. Next better is the "plunger," but the mechanical contrivance that supports the water is liable to be smeared.

742. Next are the "hoppers," long and short. These have no movable machinery and are plain bottomless bowls set upon a trap that opens directly into or is a part of the soil-pipe, the water entering by a rim-flush from an overhead tank.

743. The chief objection to the hoppers is that the walls may be soiled and the natural flush will not cleanse them.

744. The short hopper is the better of the two within the house, because the level of the seal is nearer the seat and the trap is in view.

745. For out-houses the long hopper is better, because of less exposure of the trap to frost.

746. The best variety of water-closet yet devised is the "washout," of which there are several patterns. This holds a certain quantity of water, and is flushed by a strong gush of water through the rim from an overhead tank.

747. Each closet should be supplied with its own flushing tank, to avoid contamination of the drinking supply; the discharge from the pipe should be by a $1\frac{1}{4}$ in. pipe at the least, to give adequate head; and the flush should be by the rim, to scour the bowl.

748. Water-closet fixtures should be freely exposed for inspection and never be boxed in.

749. For public buildings with closets in frequent use, copious automatic flushes arranged to discharge at regular intervals are safer than those depending upon individual care at the time.

Sewer-pipes.

750. Small waste-pipes are the more efficient, because the friction is less, and the greater the pressure the greater the velocity with less chance of obstructive sticking.

751. Waste-pipes for single fixtures need not exceed $1\frac{1}{2}$ in. and should not exceed 2 in. in diameter. For soil pipes 3 to $3\frac{1}{2}$ in. is ample.

752. The outlets of all waste-pipes should be full-bore and they should join the main soil-pipes at an acute angle.

753. Sewer-pipes that also carry storm-water should be smallest at the base; otherwise solid matter would lie in bars when sewage alone is passing.

754. Sewer-pipes should be water-tight to retain liquid sewage.

755. But pipes intended only for storm-water are sometimes laid dry, in order to drain the ground.

756. The amount of sewage should be approximately calculated in advance, and the conduit built for it.

Traps and Seals.

757. Having secured a closet that will discharge its contents without contaminating itself, the next point is to prevent the sewer-air always present in the pipes from escaping through the water-closet into the dwelling.

758. This passage of sewer-air is prevented by a trap and a seal.

759. A trap is a mechanism containing a fluid that seals the waste-pipe, to prevent the upward passage of sewer-air.

This fluid is generally water.

760. The conditions of its efficacy are that the seal must be complete and the trap be such as will not itself become foul.

761. The advantage of a trap is, that when sealed it presents a more or less complete obstacle to the passage of air.

762. Its disadvantages are that it furnishes a check to the flow of water through it, an obstacle to the escape of refuse, that it is liable to become fouled by use, and that the seal may be lost entirely.

763. Traps should be self-scouring when properly set, the outlet of the bowl a little larger than the inlet arm of the trap, and the inner surface perfectly smooth, which implies its construction of earthenware or enamelled iron.

764. The trap in common use until recently was the "D," the objection to which is that it will accumulate filth behind an interior recess.

765. The best traps are the "P" or "½ S," "¾ S," and "S."

766. A running trap is a shallow U-like bend in a nearly horizontal pipe. It should not be deep enough for refuse to lodge.

767. All the water in the trap should be changed with each flush sent through it, and there should be a good supply of clean water left in the trap.

768. This point of use is often overlooked in the kitchen and laundry sinks, the bath-tubs, and the wash-basins, so that the water remaining in the trap is apt to be the last running out of the vessel.

769. Waste-pipes should join soil-pipes, and soil-pipes mains, by Y's and not T's, and the descent of the soil-pipe should be as direct as possible; and when carried laterally the waste-pipe should be over a decided grade with the fewest possible turns.

770. A seal may be forced by the sheer momentum of the water pouring through it, it may evaporate, it may be broken by back-pressure or by siphonage.

771. Serious evaporation is not likely to occur in an occupied house. The remedy is to fill the trap with oil.

772. Back-pressure is the consequence of a heavy column of water descending the main soil-pipe to near its end, where there is an abrupt bend, or some

other obstacle to the escape of the air in front of it. This air being compressed moves in the direction of the least resistance up the branch pipe and through the seal.

773. To produce back-pressure the descending column must have acquired considerable velocity and there must be an impediment to the escape of the air before it. The fixture whose trap is forced will therefore be near the bottom of the stack.

774. Siphonage is the effect of a heavy column of water falling suddenly down a soil-pipe and thus producing a partial vacuum, by which the equilibrium of the seal is destroyed and it is broken by atmospheric pressure from within the closet.

775. Back-pressure and siphonage are complemental, and both cannot occur to the same fixture.

776. The loss of a trap by the momentum of water poured suddenly through it is a species of siphonage.

777. A vent is a pipe in the top of the bend connecting with either the soil-pipe or a general vent pipe, to admit air and so prevent siphonage. It will also counteract back-pressure. It is chiefly required in large houses or those with complicated systems of plumbing.

778. The objections to vents are their liability to become clogged by soapsuds, etc., splashing against the opening in the trap, and their tendency to evaporate the seal.

Other objections, apparently not very well founded, are made to vents by very late writers.

779. The vent should be the full size of the trap, at least up to two inches.

780. A trap vent that preserves the equilibrium by introducing fresh air from the interior of the dwell-

ing, and uses mercury to prevent the backward flow, has lately been introduced, and appears to be satisfactory.

781. Venting waste-pipes and ventilating soil-pipes are distinct.

782. There are other difficulties to be met with in plumbing, and it is not sufficient for a quartermaster to assume that because a contract has been made to introduce fixtures that that is all that is necessary. Nor for a commanding officer to suppose that, when plumbing is complained of, a broken pipe or a leaking joint is the only imperfection.

Disconnection.

783. A sewer is "disconnected" when there is a large vent, either with or without a running trap, outside of the house, allowing the free ingress of fresh air or the exit of foul air as the pressure may determine.

784. The "disconnection" is conventional rather than actual, and it is difficult to carry out in snowy or very cold climates.

785. The running trap may be dispensed with when the sewer into which the soil-pipe discharges is fairly kept, or if it is liable to be frozen, or if the grade is not good. It is chiefly required in houses not connected with a good sewer system.

786. When this trap is used, the vent must be between it and the house.

Ventilation of Sewers.

787. The third and very important method of preventing house infection from sewers is by ventilation.

788. Ventilation means the free passage of air through the soil-pipe, thus relieving the seal of undue pressure.

789. This is accomplished by extending the soil-pipe full calibre above the highest closet and through the roof into the open air, with the end free.

790. The soil-pipe thus extends from the sewer beyond the roof with no obstacle from end to end except, possibly, the running trap. (Par. 766.)

791. But as ventilation requires an inlet as well as an outlet, there should be a vent of full size, connected with it by a branch pipe outside the house.

792. Generally speaking sewer air will not escape by the vent, but will rise in the heated soil-pipe within the house; nevertheless, windows or air-ducts into the house should not be near the vent.

The Soil-pipe.

793. The soil-pipe receives the discharges from all the water-closets and other fixtures within the house, and conducts them to the sewer. (Outside of the house it is sometimes called the branch sewer-pipe.)

794. It should be of iron within the house and of earthenware (tile) outside of it.

795. It should have a calibre not to exceed 4 inches for the largest public buildings, while from 3 to $3\frac{1}{2}$ inches is ample for ordinary private houses.

796. It must extend full bore above the roof and be somewhat larger at that exit, on account of accumulating frost.

797. The part above the upper closet must be of the same material and construction, to avoid leaks.

798. The whole pipe should be tested by water pressure for leaks, when set up.

799. It should have as few changes of direction and those over as large curves as possible, and should never be carried horizontally, nor under buildings if it can be avoided.

800. Where the soil-pipe passes out of the house it should be protected by an arch in the wall.

801. It should have full bore connection with the open air outside of the house wall. (Par. 791.)

802. The water-closet should join it at an acute angle and by as short a pipe as possible.

803. The upper extremity of the soil-pipe should not be curved nor be covered by a cowl.

It should terminate below the level of the chimney top and not be near a window into which the gases from it may drift.

804. Neither the soil-pipe nor the vent-pipe should be allowed to terminate within a chimney, as is sometimes done; because the fires are not perpetual and down drafts frequently occur. Such pipes also are liable to be choked with soot.

805. Suspected leaks are searched for by peppermint or smoke.

806. In large houses the vent-pipes are sometimes run together upward in a single pipe. In smaller houses they may enter the soil-pipe above the highest fixture.

807. Rain leaders sometimes conduct storm-water from the roofs into the sewers. They will ventilate upward as well as carry water down, and therefore those near windows should not be thus used.

808. Under no circumstances should they discharge on the sewer side of the trap or of the vent, and there always should be a vent.

809. It occasionally happens that, impressed with

the desirability of removing sewage from habitations, post authorities have used wooden drains through which to discharge such excreta.

It is only a short time before such conduits become clogged and saturated with their contents, and are thus transformed into long permanent cess-pools.

Privies, etc.

810. But water carriage of excreta is the exception in the army; nevertheless excreta and garbage generally must be disposed of, and that promptly.

811. At posts after a well-ordered sewer-system come, in order of desirability, (1) privies over the water, as may be arranged on the sea coast: (2) cess-pools; (3) privies; (4) the dry-earth system; while for the future, and better than these, is the furnace.

812. A cess-pool is a cistern, generally walled dry, with a floor of earth. Into this the house waste is conducted by pipes and from it the liquid matters drain and the solids are removed as required.

813. For its proper use, the soil must be porous and the water supply be beyond contamination.

814. A deep dry-walled privy, covered and when full abandoned, is a variety common at some posts. These should be, but rarely are, permanently marked to warn future garrisons.

815. The worst privies are the common shallow pits dug for temporary relief, generally without authority, near stables, corrals, and married men's quarters.

816. These are often filled to repletion, insufficiently covered and unmarked, honey-combing an old post.

817. Such pits should only be dug by authority, speci-

fically designating place and depth, filled in according to rule, and marked in place and on the post map.

818. Such care is especially important when the water is drawn from wells or superficial reservoirs.

819. The dry-earth system depends for its efficacy on the disinfecting—or deodorizing—power of really dry earth, not sand or coal ashes and the like, covering the discharges at once.

820. This is extremely difficult to carry out systematically and well. Sometimes the discharges are carried in movable drawers at daily intervals to another place of deposit, but always with considerable risk of distributing part of their contents.

821. Human excreta should be carefully disposed of, because discomfort and danger follow exposure to infecting matters from them, such as are liable to be present in solution in the drinking water or floating through the air, dried and invisible.

It is not enough that they are out of sight. They should be thoroughly buried if not burned:

Kitchen Slops.

822. Kitchen and laundry slops are liable to be hurtful, because they contain in solution and suspension animal and vegetable débris, which certainly undergo decomposition, and are liable to be charged with emanations from the body in disease as well as in health.

823. The ground on which slops are habitually thrown is often indescribably foul by soakage, and yet few people suspect such waste as harmful.

824. All waste going out of a house, not into sewers, should be received in water-tight barrels, which should rest on superficial platforms.

825. The ultimate destruction of all garbage should be by fire.

Garbage furnaces are now in use in many cities that effectually destroy all refuse without odor and at moderate cost.

826. Pending that, and in the absence of deep water, refuse should be carefully separated into the destructible (organic débris), like slops, old clothes, decaying vegetables, and the indestructible, as tin cans, pottery, etc.

The former should be buried in deep and remote trenches when the weather permits, and the latter be cast away by itself.

827. When water is introduced into a post by a pipe system, pains must be taken at the same time to have it systematically carried away. Otherwise the surplus water will saturate the ground, often already full of organic waste, and under heat disease will arise.

This is an oversight that occasionally occurs.

VII.

WATER.

828. Water is more immediately necessary to life than food; and as a carrier of disease-causes it is one of the general sources of preventable disease.

829. The clouds are the ultimate source of all water supply, they being replenished by evaporation.

Cisterns.

830. Rain-water, collected from a clean surface, after the atmosphere has been well washed, is the purest in nature; but its storage is so difficult as to degrade cistern water from the first rank.

831. In collecting cistern water, unless the surface is very clean the first rainfall should run to waste or be very carefully filtered.

832. Cisterns rapidly deteriorate, and when of wood the fluctuating water-line fosters decay.

833. Underground cisterns, usually of cement-lined brick, are liable to leakage into them through cracks or from the surface.

834. Overflow pipes should not connect with sewers, lest foul air come over and be absorbed.

835. The washings of roofs introduce a rapidly-decomposing sediment.

836. Clean gravel will introduce into wooden cisterns the bacteria of nitrification, which are purifying agents.

837. To determine the quantity of water that may be collected from a non-absorbent surface, multiply the area by the rainfall.

838. To do this, reduce square feet to inches ($\times$ 144), and multiply this by inches of rain, which will equal cubic inches of rain. Divide this by 1,728 for cubic feet, or by 277.274 for gallons.

839. The area of roofs is that of the horizontal plane covered, not of the slopes.

Springs and Wells.

840. But most drinking-water comes directly from streams (including ponds), springs, or wells.

841. The rain which soaks directly into the ground, either at hand or afar, and is held by an impenetrable stratum, constitutes subsoil water. (Par. 489, 495.)

842. But a deep water supply is almost everywhere to be found below the subsoil or ground water.

843. This is derived from rain-water following the lines of upturned strata directly through impervious layers, until it is held at a great depth either in local reservoirs or in immense beds whose origin may be far distant.

844. Wells may draw their water from either source, and it is practically impossible to determine from which without a fair knowledge of the local geology.

845. The arbitrary rule, to which there are many exceptions, is: Wells less than fifty feet deep are shallow, from subsoil water; more than 50 feet deep, from deep water-bearing levels.

846. London and Paris both lie over impervious basins into which water drains from great distances. It can be reached by the artesian method.

847. But New York is underlaid by rocks lying nearly perpendicular to the horizon, so that its subjacent water is practically surface water that has soaked directly downward.

848. If the surface is not polluted, water in shallow wells is as good as that in deep wells. But where the soil is contaminated it is only a question of time when the well, whatever its depth, whose water passes through it, becomes equally foul with a shallow one.

849. Ordinary well-water in an inhabited region is doubtful, and houses standing 100 feet apart should condemn all intervening wells.

850. The rule is general that wells drain inverted cones whose radius equals their depth. In sand the area is much greater, and any well may receive a supply, pure or impure, through a fault.

851. The longer the neighborhood has been inhabited, the greater the risk.

852. Water that is contaminated, especially with animal waste, is not necessarily disagreeable; it is apt to be more sparkling and may be very pleasant.

853. No one would willingly drink sewage, yet sewage is not necessarily disease-bearing, but it is at any time liable to become so by a specific taint being imparted.

854. The most of the water in a well on the bank of a river does not come from the river, but from the intercepted subsoil water making its way toward the stream.

855. Wells should collect water going towards, not coming from, a polluted site; and no well, even in search of deep water, should pierce a polluted basin, because the shaft is liable to conduct water from the upper to the lower level.

856. Springs whose origin is remote from habitations, large lakes, and streams flowing through uninhabited regions furnish the best sources of water supply, except rain-water from a perfectly clean surface in a protected reservoir.

Solution and Suspension.

857. Substances in solution completely disappear and cannot be filtered out; e.g., salt in water.

858. In suspension the particles do not entirely disappear, and their presence is shown by turbidity or opacity.

859. But water may be colored and yet transparent, or at least translucent; e.g., solution of sulphate of copper, cypress swamp water.

860. Water may contain mineral matter in solution, mineral and organic matters in suspension, and organic matter in solution of varying qualities, some harmless and some accompanied by, if not distinctly made up of, specific disease-causes.

861. The alkaline waters of the plains contain great quantities of soda, potash or magnesia.

They are more disagreeable in the rainy season from the alkali, left on the surface of the soil by evaporation, being washed into the wells.

As far as known, they may only be purified by distillation.

Hard Water.

862. The hardness of water is caused by the presence of lime, magnesia, iron, baryta, alumina, or certain other minerals.

It is divided into temporary and permanent; it

renders cooking of certain vegetables very difficult, and compels the use of a great deal of extra soap to neutralize the hardness before washing can be done.

863. Persons accustomed to drinking soft water generally have some intestinal trouble after drinking hard water, and the reverse is true.

864. Hard water is generally bright and sparkling.

865. In practice hardness is recognized by the curdling that follows when there is an attempt to dissolve soap in it.

866. Soaps are alkaline oleates which quickly form a lather when mixed with pure water. But if the substances that give hardness to the water are present, oleates of those bases are formed and no lather is given until the bases are thrown down.

867. Resting upon the foregoing is the soap test for hardness, where a standard solution of soap is used to neutralize these bases, and the degrees are established according to a certain scale.

To Remove the Hardness of Water.

868. The hardness of water is divided into temporary and permanent or fixed, the sum of the two constituting the total hardness.

869. Ordinary hard water is so from the salts of lime and magnesia in solution and from free CO_2.

870. Much of the hardness depends on the bicarbonates of lime and magnesia in solution and on the presence of CO_2.

871. Now in boiling water for half an hour the heat dissipates the CO_2 and transforms the bicarbonates into simple carbonates, which being insoluble are precipitated.

This leaves certain soluble lime and magnesia compounds (usually sulphates) which cannot be extracted.

872. Or, in a small way, add carbonate of soda (washing soda). The reaction leads to bicarbonate of soda and carbonate of lime. The soda bicarbonate is soluble, but the insoluble lime carbonate is precipitated.

873. Or, the third and best method, known as Clark's process, depends on the addition of lime. This is applied on a large scale, the quantity of lime being determined by the soap test.

874. The lime subtracts a certain amount of CO_2 from the soluble bicarbonate of lime, converting it into an insoluble carbonate which, with the carbonate originally present, falls to the bottom.

875. When there are 20–30 parts bicarbonate of lime per 100,000, about 9 oz. quick-lime is used to every 400 gals. of water, or one gallon clear lime water to every ten gallons of water.

876. The following illustrates the comparative cost of the materials for neutralizing equal amounts of hard water. To the lime process, which is used on a large scale, the cost of labor and apparatus must be added:

1 cwt. lime, ...	=	$ .50
5 cwt. soda, ...	=	$ 6.00
20 cwt. soap, ...	=	$130.00

Suspended Matters and Their Removal.

877. Water may contain in suspension as well as in solution both organic and mineral matter, and it is against this suspended matter, which is offensive to

the eye, that the most of the processes of clarification and filtration are directed.

878. Muddy water usually contains insoluble particles of slightly greater specific gravity than the water itself, and when allowed to rest sedimentation will free it from most of the foreign matters, and, speaking generally, the remainder can usually be removed by straining.

879. Settling basins on a large scale is one of the important adjuncts to reservoirs.

880. But excepting diarrhœa from mechanical irritation, mud, although unsightly, rarely causes disease.

The diarrhœa, however, sometimes is grave and persistent.

881. Settling, by rest, on a small scale is often efficacious for domestic use.

882. Suspended matters are removed by precipitation and filtration.

Precipitation.

883. Precipitation is either sedimentation by rest (as just described), or through clarification which, by inducing changes through harmless chemical action, leads to it.

884. The most convenient agent, especially if the water is slightly hard, is alum.

Use about six grains of crystallized alum to the gallon, or move about in the water a lump of alum held in the hand.

885. Some years ago, one wing of a British regiment passing up the Indus drank the water without preparation and suffered severely from diarrhœa. The

other wing used alum and had no diarrhœa. The first then adopted it and the diarrhœa ceased.

886. The rationale is the formation of calcium sulphate from calcium carbonate which, together with the bulky aluminum hydrate, entangles the suspended particles and sinks with them.

Should the water be very soft, first introduce a little calcium chloride and sodium carbonate.

887. Cactus leaves cut up have a similar clarifying effect.

888. Other methods are: The use of perchloride of iron, 1 oz. tc 250 gal., following it by 2¾ oz. carbonate of soda to neutralize the acidity and remove the excess of iron.

889. Borax and alum, 3 oz. of each to a barrel (31½ gal.), have been recommended. (This appears excessive.)

890. Citric acid, 1 oz. to 16 gal., improves water by its action on contained minute vegetable growths (algæ).

891. Tannin in small quantities has the same effect; but when tannin is used the water should stand some hours.

892. Growing vegetation, although the water may be colored green thereby, is usually of advantage, but dead vegetation may do harm.

Filtration.

893. Filtration is chiefly directed against suspended matters, but it may also influence dissolved organic matters.

894. Filters have three modes of action:

(1.) By mechanically arresting suspended matter

too large to pass through their pores. That is straining.

895. (2.) By the attraction of masses, as when water passing very slowly through a filter makes deposits in the interstices.

896. (3.) By the removal of substances actually dissolved in the water.

897. With sand filters there is practically no influence on dissolved mineral matter, unless it is possible for a chemical change to occur. E.g. If CO_2 is absorbed by the filter, it is possible for lime carbonate to be deposited from the bicarbonate in the water.

898. On the other hand, if the gravel and stones contain soluble ingredients, there may be more mineral matter in the filtered than in the unfiltered water.

899. Of organic substances a very small but appreciable amount may be removed by sand filtration.

900. Most porous substances remove certain kinds of organic matter by adhesion.

901. Organic matter may be destroyed by oxidation through the air that always exists in the interstices of the filter.

902. But both of these actions are limited, and for their continuance the material must be frequently renewed.

903. But filtration on a large or a small scale has for its main object the removal of suspended matter.

904. The chief materials are the following:

(1.) Sponge, wool, and similar articles, having a temporary value in straining gross matter but requiring prompt renewal, lest they communicate more impurity than they remove.

905. (2.) Sand, which has little or no effect on dis-

solved organic matter, but removes suspended substances.

906. (3.) Porous stone, which acts in the same way, but is cleansed with difficulty. Organic matters adhere to it slightly.

907. (4.) Iron sponge, a compound of sawdust and iron oxide heated in a furnace. It is a porous mass of charcoal and metallic iron and is efficient for the removal of mineral matter.

908. (5.) Bone-black or animal charcoal; to be used when freshly burned. It absorbs mineral matter for about a fortnight, but its chief action is on organic matter.

909. (6.) Vegetable charcoal, to be similarly used.

910. (7.) Carferal, a proprietary substance recently put upon the market.

It is black and granular, like granulated animal charcoal, and consists of charcoal and iron in small quantities, with a basis of clay.

Its designation is derived from the first syllables of those names in Latin: *Car*bon, *fer*rum, *al*uminum.

911. Carferal is efficacious while of good quality, but like all proprietary articles the uniformity of its composition is never certain.

912. Filtering materials act through a limited period without renewal, and on an average should be cleansed once in two months.

Hence inaccessible filters should be condemned.

913. The ordinary portable individual filters are practically only strainers. They should be frequently washed and brushed with a stiff brush and afterward washed with a solution of permanganate of potassa.

914. Tank filters on a large scale are of different styles.

(1.) Some have a porous partition of brick or stone between the entrance and exit pipes.

915. (2). Others have a cut-off portion filled with gravel, charcoal, and sand, through which the water passes into the permanent reservoir.

916. (3). Probably the best form is where the fil tering material is raised a few inches above the bottom, the water is admitted at the bottom and taken out at the top, and this lower space serves as a settling basin.

917. An excellent field filter is a cask charred on the inside (that may occasionally be brushed), pierced with small holes through the bottom, sunk in the source of the water supply.

918. Still better is one barrel within another, the outer pierced through the bottom and the inner near the top, the intervening space being filled with sand, gravel or similar material.

Disease-causes beyond the Control of Filters.

919. But the most important evils associated with water are not tangible in the ordinary sense, and filters act upon them within very narrow limits, if at all.

920. Several grave diseases are intimately associated with water as a cause-bearer, if not as a cause.

921. These are cholera, typhoid fever, and a variety of dysentery, which are spread chiefly by discharges from infected persons that gain access, as a rule, to the new victims by the mouth with food and drink.

922. The most common mode of propagation, at least of the first two, is through the drinking water.

923. It is by the soakage of such discharges into wells, or by their contamination of the larger streams or reservoirs, that such epidemics generally occur.

924. It has not been demonstrated that typhoid fever may originate from sewage not specifically poisoned; but it is certain that both it and cholera are caused by their specific excreta.

925. Now, as both typhoid fever and cholera begin with a painless diarrhœa whose import the invalid does not understand, it is quite possible for such discharges to drain into any but the best kept water supply.

926. In this way epidemics of great magnitude sometimes begin.

927. A year or two ago the washing of the discharges of a single case from the bank of a stream into the stream itself that supplied water to a settlement, was followed by an epidemic of 1,000 cases of typhoid fever resulting in many deaths and great loss of time and labor.

928. Several years ago two factories employing many hands stood side by side, but the men drank from two distinct wells. One of these wells was pure and the other was believed to be infected. Of those who drank from the infected well, 600 died of cholera; but of the others, none.

929. A severe and fatal variety of dysentery has repeatedly been traced to impure water; water not so far as known charged with dysenteric products, but flooded with filth.

930. Sewage-tainted wells do not necessarily induce disease, but the sewage in them is at any time liable to become specifically infected without any change in their physical appearance.

931. Such water is sometimes more clear and palatable than that in good wells, and it often is difficult to persuade those accustomed to them of the truth,

or to make them understand how leakage may flow over long and unsuspected routes.

932. The worst cases (in fact, not in appearance) are the unsuspected—for had they been suspected their use would not have been persisted in.

933. A well nearly free from iron suddenly began to yield chalybeate water, which deposited an ochreous sediment. It proved that a quantity of spoiled beer having been emptied into the ground 115 feet from the well, its organic matter acted as a reducing agent on ferric oxide in the soil, which dissolving as a protocarbonate entered the water that supplied the well.

934. Gas from a main 1,000 feet away has been recognized in well-water.

935. The typhoid poison has been conveyed a mile by an underground flow.

936. The feature of limestone regions, that they are peculiarly liable to fissures and subterranean caverns through which water freely communicates over long distances, makes them eminently subject to the spread of cholera.

937. Should a suspected well materially differ chemically from neighboring wells, it is probably infected. The chemical condition in this case being an indication, not a cause.

938. A chain of wells of course may be similarly affected, in which case special investigation must be made.

939. If a specific source of contamination is suspected, the simplest way to determine whether a communicating channel exists is to introduce into the cesspool or other suspected locality a quantity of salt or brine and later to observe what change, if any,

there is in the chlorides in the well. If they have increased, the inference that the contents of the privy may enter the well is obvious.

940. Lithia, which is not found in ordinary soils, is a more delicate test.

941. Specific disease-causes may not be extracted by filtration, nor respond to chemical tests, nor be antagonized by chemical agents, at least so that the water remain potable.

942. But there are chemical indications by which sewage may be suspected.

943. These are the presence of chlorides, of nitrates, of nitrites.

944. When these are reported they are to be looked upon as signs of sewage or similar filth, unless there are plain indications of their origin from perfectly innocent sources.

945. Like CO_2 in the air, unless in enormous quantities, they are harmless in themselves, but they are an index of other mischief.

946. The special evils to be dreaded in connection with polluted water supply are typhoid fever, cholera, and perhaps dysentery.

947. "Unfortunately, the typhoid fever germ is neither separated from the water nor destroyed by the oxidizing and nitrifying bacteria of the soil. The ordinary or non-specific organic matters of sewage may be turned into harmless nitrates which give a sparkle to the water of the well, although it may contain the cause of typhoid fever which has undergone percolation unscathed." (Smart.)

948. The same is true of the stream into which sewage is discharged; the weaker agencies of running

water are not apt to succeed as purifiers when the more powerful natural filtration fails.

949. The cholera-cause, like that of typhoid fever, also probably escapes change, at least for a considerable period, when only influenced by natural agencies.

950. It is therefore much better to avoid the original pollution of water supply than to attempt to remove the poison once introduced.

951. Independently of the specific disease-poisons intimately associated with water-carriage, there are non-specific impurities generally held in suspension but sometimes in solution.

952. These may come from animal waste or even from animal decomposition, as in the soakage of graveyards, and from vegetable decay.

953. Organic remains in water are always impurities, never being present naturally, as in some sense the minerals that are in solution might be regarded.

954. But in view of the inconceivable amount of organic disintegration going on through all time, why is not all water a mere vehicle to carry this waste?

955. Because the free oxygen in the soil and in the water allows unrestrained oxidation, and because certain minute organisms associated generally with mineral matter and known as the bacteria of nitrification, decompose the waste, freeing ammonia.

956. With the presence of ammonia, nitric acid and subsequently the nitrates and nitrites are formed.

957. The nitrates and nitrites therefore are indications that animal waste has been present in the water.

958. When waste has reached that stage its power

for evil has gone, but more waste may follow too rapidly for the soil to neutralize; the excess may be there already.

959. Concentrated waste in the shape of sewage must overcome the regenerating influences of a limited area, and these indications of pre-existing danger must lead to the suspicion that danger itself is not far off.

960. The preceding chiefly concerns wells towards which surface slops, broken sewers, or imperfect vaults may drain.

The Detection of Organic Waste.

961. There is no easy test for organic matter in water, but the following is a chemical hint:

962. Half fill a quart bottle with water at 70°–80° F.; shake it vigorously, and then if a bad odor is detected, it is doubtful or bad.

963. But all bad waters do not have an odor. Therefore evaporate 3 or 4 oz. to perfect dryness in a porcelain or platinum capsule, and then ignite the dish.

If there is no blackening or an easily dissipated darkening of the residue, the water is probably good.

If the crust blackens, there is probably carbon from an excess of vegetation.

If nitrous fumes are evolved and the carbon sparkles with energy, animal matter may be suspected.

964. The permanganate salts are rich in oxygen, that is easily given up.

Added by degrees until the oxygen is absorbed, permanganate of potash colors water a rich pink or red.

965. The permangante is useful to cleanse filters, and to indicate organic matter but not the kind (it shows beef soup and street filth equally); and although a valuable adjunct it cannot be depended upon to neutralize real disease-causes.

The Ultimate Disappearance of Sewage.

966. What becomes of the vast quantity of sewage poured into running streams—often streams that sooner or later furnish drinking-water for communities?

967. It is generally said that streams purify themselves.

In a rapid stream there is much oxidation; the solid matter is acted on by the bacteria of decomposition; sedimentation takes place literally, or practically by the suspended silt enveloping the particles of sewage.

Dilution has much to do with its apparent disappearance; the volume of water is very great and the sewage becomes immensely attenuated.

968. But even specific organic particles do disappear in some way, and the accumulation of deadly poison, that *a priori* would seem necessary, does not occur.

969. Nevertheless, the discharge of sewage into streams whose banks are inhabited should be forbidden by law, as it now is in England.

970. As a rule, and always finally, subsoil water tends towards the river-courses.

It either swells the river by its direct volume, which is the reason why a stream increases as it descends,

independently of tributaries, or it forms a subaqueous river.

In most cases both are true, and in objectionable rivers good water may generally be found by piercing the gravel bed of the river proper and pumping from below.

Supply for Troops.

971. On halting for camp the water supply must be immediately guarded, and with special precaution if it is small.

972. Great care must be taken that the margin is not trampled into mud, and the water made turbid.

973. By moderately digging out a small spring and sinking a casing or barrel, the supply will be increased.

974. If the stream is shallow, promptly make a small reservoir by a temporary dam for drinking, one below for the horses, and one still lower for washing.

975. Horses will drink better and more rapidly where the water is five or six inches deep, which can easily be arranged.

Where the supply is limited, an officer should be in immediate charge of the whole.

976. A horse drinks about 1½ gal., requiring three minutes.

977. At a permanent camp where the command is large in proportion to the water supply, make one or more reservoirs to retain the water that flows by night, and draw from them the cooking and drinking water.

Extend lower down a single or double row of sunken half-barrels for horses, all connected by little gutters to avoid waste, and conduct the surplus into a still lower reservoir.

978. On the march a man requires for cooking and drinking 6 pints a day, increased in hot climates to 8 pints, and an equal amount for washing the person.

979. In stationary camps 5 gal. for all purposes.

980. In barracks, for all purposes except water-closets and bath-rooms, 10 gal. per head. With water-closets and baths, 25 gal.

981. Horses, if allowed all they will drink, require 6–10 gal. per day, and about 3 gal. per head for police purposes.

982. The foregoing are the lowest figures.

983. Hospitals require several times as much per man, depending on the character of the cases.

Ice.

984. Water parts with some of its impurities by freezing, but not enough not to require the sources of the ice supply for domestic purposes to be as carefully selected and guarded as those of water.

VIII.

PREVENTABLE DISEASES.

Malaria.

985. Properly speaking, malaria is not a disease but the cause of diseases.

986. It may be assumed to be an emanation from the soil under the fermentative action of heat, moisture, and vegetable decomposition, intended like CO_2 for the support of vegetation, whose excess not thus absorbed is hurtful to man. (Smart.)

987. This hypothesis, which assumes active vegetable growth as a condition for the absorption of the poison, accounts for its greater virulence at those times of the day and seasons of the year when vegetable growth is least active.

988. There is reason to suppose that drinking water absorbs the malarial poison, which thus may enter the system.

In this way one variety of the so-called mountain fever, arising under conditions not otherwise explicable, may be accounted for. (Smart.)

989. Whatever the nature of the malarial poison, it appears to be borne for limited distances by the wind, to lie near the ground, to be stopped by mechanical barriers, to be avoided by residence in an upper story, and to take effect most distinctly when the exposed person is poorly nourished, ill-clad, and with an empty stomach.

990. The disease-causes of malarial, choleraic, and typhoidal (enteric) disease contained in water cannot be filtered out nor antagonized chemically so as to leave the water fit to drink.

991. But brisk boiling for fifteen minutes or more renders these poisons comparatively harmless.

992. Boiled water, which is insipid, may be rendered palatable by aeration, by pouring it through the air or dashing it in a vessel.

993. It is one of the great advantages of tea and coffee as beverages, that their preparation involves the destruction or weakening of these causes of disease through the boiling of water.

Typhoid Fever, Cholera, and Yellow Fever.

994. Typhoid fever (enteric fever) is strictly an eruptive disease, and like other eruptive diseases is unlikely to attack the same person twice.

But it is very likely to prevail among newly raised troops, and therefore it requires the utmost caution to avoid its propagation, which chiefly occurs through the discharges from the bowels.

995. Cholera has nothing in common with typhoid fever except its tendency to spread through the discharges, especially from the bowels. It may occur several times in the same person.

996. The utmost caution then is necessary in disinfecting all discharges and preserving from contamination the water supply.

997. For the same reason old camp grounds, and especially those once infected, are always condemned.

998. But neither cholera nor typhoid fever is contagious by mere presence, as small-pox is.

999. It follows that it is important to disinfect the

discharges of both cholera and typhoid fever before disposing of them.

1000. It is probable that the cholera poison does not flourish in acid fluids either within or without the body, and both of these diseases spread more easily where alkaline fermentation occurs.

1001. To acidulate the excreta is one of the best preventives against these diseases spreading.

1002. Carbolic acid in excess, sulphate of iron (copperas), or, best of all, mercuric bichloride (corrosive sublimate) are to be used for every discharge, and these must be thoroughly disinfected before committal to the sewers.

1003. Should there be no sewers, similar disinfection must be practised and the whole be buried beyond any possible contamination of air or water.

1004. Everything contaminated by excreta of any kind in these diseases is to be similarly and completely disinfected, and especial pains taken to preserve the purity of the water supply.

1005. Should there be danger of an outbreak of cholera, in the absence of direct medical advice it would be well in addition to boiling the water to put the command on an acidulated drink, as "lemonade" of aromatic sulphuric acid. This is believed to have prevented the disease in special communities.

1006. Yellow fever is a disease of navigable regions in hot and moist climates that, as a rule, does not twice attack the same person.

1007. Usually if not invariably imported, its foci of greatest virulence coincide with the centres of animal filth.

1008. A locality becoming infected, the only safety for the susceptible inhabitants is emigration until frost.

1009. The contagiousness of yellow fever, like that of typhoid fever and cholera, does not reside in the sick person as such, but in his excreta under developing conditions.

1010. In a dry and elevated rural district yellow fever will not spread, either from a patient or from infected material.

1011. But the introduction of such infected material (as bedding, baggage, etc.) into susceptible localities will give rise to the disease.

1012. The disease-cause in yellow fever infects the air and not the water.

1013. The disease-cause travels from its focus with a well-defined and relatively slow pace. It does not develop with explosive violence simultaneously over large tracts.

1014. General safeguards are extreme cleanliness, especially as to animal filth, and the exclusion of infected material.

1015. Individual safeguards are temperate habits, freedom from depressing influences, avoidance of all filthy localities and of the night air.

1016. Quarantine, as such, is a useless annoyance.

1017. But all infected material must be thoroughly disinfected.

1018. The removal of troops into camp, if only a few miles away, before the outbreak or at any stage of it, will limit the progress of yellow fever and will not infect a sanitary neighborhood.

Contagious Diseases and Disinfectants.

1019. Measles and mumps are contagious diseases that almost every person has at some period of life. There is no known method of preventing them ex-

cept by avoiding their presence, which is generally impossible. As these are serious in camp, special hospital provision must be made among newly raised troops. (See par. 147.)

1020. Diphtheria, scarlet fever, and small-pox are not necessary diseases, but are contagious and are very serious.

1021. Small-pox is always to be controlled among the well by preventive vaccination.

1022. The direct contagion of scarlet fever is not strong, but its persistence is extreme, even after years of burial.

Everything connected with such a case, clothing, toys, and especially books, should be burned.

Infected rooms and houses should be thoroughly disinfected by scraping, lime-washing, painting, and scrubbing with corrosive sublimate 1: 1,000, as well as by ventilation. Small wooden houses about a post it is safer to destroy by fire.

1023. Diphtheria is essentially a disease of foul air in its origin. It is eminently infectious and clings persistently to places when once established. It probably depends on foul air to begin with, and on want of ventilation to carry it on.

Disinfection after diphtheria should be as thorough as with scarlet fever.

1024. Consumption, originating in several ways, is now believed to be a contagious disease. Unquestionably the cases are most frequent in barracks and other rooms that are the most crowded and the least ventilated. The expectoration of consumptives should be disinfected, and the air they live in not be breathed by others.

1025. "A disinfectant is an agent capable of de-

stroying the infective power of infectious material." (Am. Pub. Health Assoc.)

1026. Substances that merely neutralize bad odors are not disinfectants.

1027. The best disinfectants are "dry and moist heat; sulphur dioxide; the hypochlorites of lime and of soda (chloride of lime and Labarraque's solution); mercuric chloride; cupric sulphate; carbolic acid." (Sternberg.)

1028. "It is impracticable to disinfect an occupied apartment," but it should be carefully closed and three pounds of sulphur be burned in it for every 1,000 cubic feet. It must afterward be washed down by hand with a solution of 1 to 1,000 of corrosive sublimate, 2 to 100 of carbolic acid, or 1 to 100 of chloride of lime or sulphate of iron. (Am. Pub. Health Assoc.)

1029. For privy vaults use one pound corrosive sublimate dissolved in much water, to 500 pounds contents of vault.

In Conclusion.

1030. Finally, the efficient care of troops is a work full of prosaic detail, but the minutiæ expand naturally, so that the care of an armed man and that of an army are problems of similar factors, only varying in their power, in the science of military hygiene.

1031. Besides their physical care, the cultivation of contentment and judicious appeals to personal and professional pride are important in forming the best soldiers.

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